COLLECTOR'S EDITION: SPACE ART SPECIAL!

Astronomy®

JULY 2022

The world's best-selling astronomy magazine

50 GREATEST COSMIC SCENES OF OUR TIME

p. 6

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Vol. 50 • Issue 7

Stargazing for a Cloudy Night

Hipparchus (circa 130BCE) noticed the drift of the equinoxes, which he attributed to the precession of the celestial sphere. (We frame things differently today.) He also proposed an alternate explanation which fit the Greek cosmos: instead of the entire starry sphere shifting, perhaps it was just the equatorial region undergoing a gradual plastic deformation. What's more, he described a long-term experiment to test this idea. 260 years later, Ptolemy completed this study, in Book VII.i of *Almagest*.

The Starlines of *Almagest* is an online coffee-table picture book, a deep dive into the early history of astronomy. We review Hipparchus' experiment, which helps us see how star alignments and other geometric figures were used to define individual stars before the widespread use of stellar latitude and longitude. We also explore Ptolemy's star catalog (books VII-VIII of *Almagest*), the history of the constellations, and more.

Visit
https://starlinesofalmagest.com
to view the skies through ancient eyes, a digital stargazing experience for a cloudy evening.

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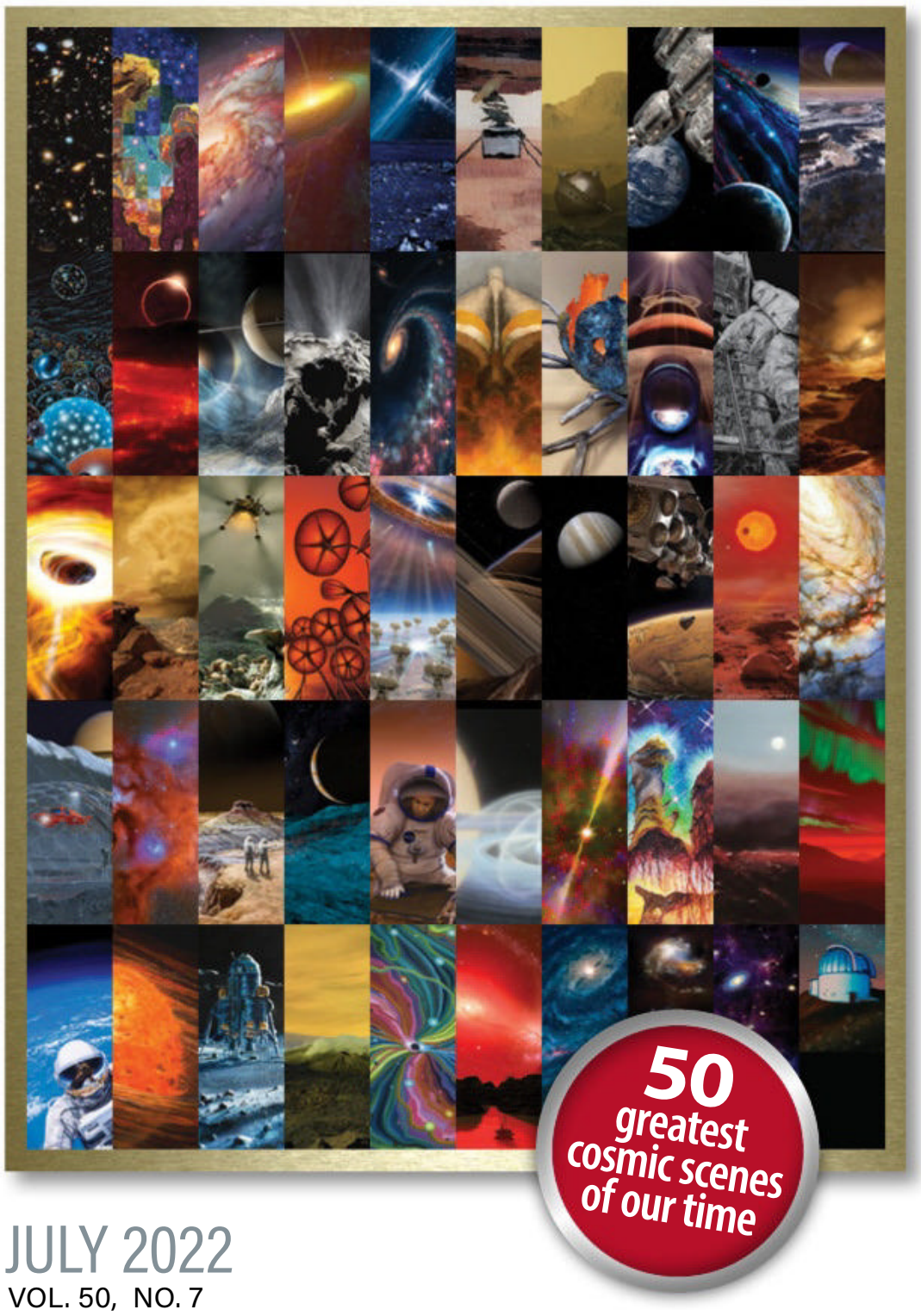

JULY 2022
VOL. 50, NO. 7

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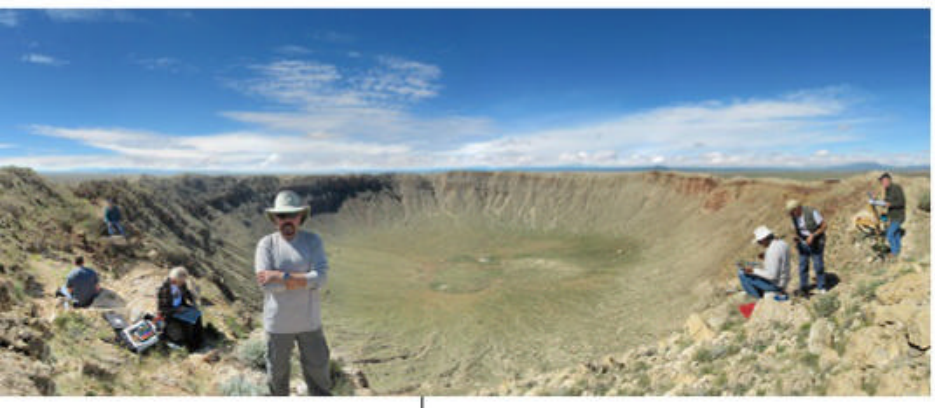
Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Media Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, PO Box 8520, Big Sandy, TX 75755. Canada Publication Mail Agreement #40010760.

Through the gallery!



Members of the International Association of Astronomical Artists paint their celestial visions at the famous Meteor Crater impact site, near Winslow, Arizona. ALDO SPADONI

Last year I attended the Spacefest meeting in Tucson for the first time, where I met a number of astronaut friends and also a world of astronomical artists. The meeting brings together many members of the world's leading organization for space art, the International Association of Astronomical Artists (IAAA). At the show, I came up with the idea of producing something that has never been done before — an issue of *Astronomy* magazine solely devoted to the magnificence of the best current space art. You hold the result in your hands.

Many years ago, the magazine's founder, Steve Walther, devised a slogan for our title that also served as a clarion call for of publishing space art: "Man's dreams of worlds unseen." The magic of this art is that it can carry us across vast distances of the universe to show us close-ups of places we will never see in person.

Members of the IAAA have been paramount in creating those visions, and here we present 50 of the greatest recent works of art, laid out for you to enjoy as if you were walking through a museum gallery. Thanks go to Aldo Spadoni, the IAAA's president, for helping to coordinate this special package.

Founded in 1982, the IAAA contains more than 130 talented members; the 42 artists who contributed works in this issue are listed on page 66, along with their website addresses. You can read all about this group of artistic trendsetters on the IAAA's website, iaaa.org. Members of the group have also created a wonderful book, *The Beauty of Space Art*, edited by Jon Ramer and Ron Miller. The book was published in 2021 by Springer Nature and contains a vast number of works of art beyond those included in this issue.

Our presentation is divided into four sections, covering spaceflight, the solar system, the Milky Way, and the distant universe. The authors, Spadoni, Miller, Ramer, and planetary scientist and artist Bill Hartmann, represent the cosmos as well as anyone ever has. Enjoy!

Yours truly,

David J. Eicher
Editor

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Chesley Bonestell's art, like this imagining of Saturn from the surface of Titan, helped ignite the Space Age.
CHESLEY BONESTELL

We welcome your comments at Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; or email to **letters@astronomy.com**. *Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Sci why?

Yvette Cendes' article, "How to swallow a star" (December 2021), stood out because while it was informative, it was her personal experience that made it relatable. Describing the middle-of-the-night alert saying an image of a TDE was ready to view, going in depth about them, then ending with what she sees on her screen and what tasks lie ahead was a great way to add a glimpse of her life into an amazing and informative article. Adding the fact that she was inspired by Carl Sagan's *Contact* was a nice reminder that that sort of inspiration is an important catalyst to many people's careers. I think it would be neat to see an article that focused on WHY astronomers do what they do and what inspired them to study the cosmos! **—Philip Ginn,** Santa Fe, NM

A grim legacy

I enjoyed Fred Nadis' "When the Atomic Age met the Space Age" (March 2022) and appreciated that he pointed out that Wernher von Braun's first successful rocket, the V-2, led to 5,000 deaths in its target cities. The beginning of the Space Age was tragic. Any mention of this history ought to include the other victims: some 20,000 slave laborers who died building the V-2 under appalling conditions. Von Braun knew of the slaves and their concentration camp horrors; at least once, he calculated the number of slaves needed to make part of the manufacture process more efficient. We must reckon with this legacy. **—Christopher Cokinos,** Salt Lake City, UT

How to announce aliens

I was somewhat amused by the seven levels of evidence for the existence of alien life (March 2022). Clearly you left out the most important and definitive eighth level — the one where we intercept a message from aliens heading in our direction. The message would be simply: "Look what's on the menu." **—Stuart Liebowitz,** Roseburg, OR

The power of art

Your March 2022 article, "When the Atomic Age met the Space Age," does not give credit to the real inspiration of the '50s: the artist and visionary Chesley Bonestell. It was his creative and technical skill published by *Collier's* magazine that was distributed worldwide and first excited me in space travel. Who can forget Bonestell's incredible space structures and impressions of the planets of the solar system? I would encourage *Astronomy* readership to revisit Bonestell's astonishing futuristic visions and the products of his pen and brush. **—Chris Miles,** Orlando, FL

From the editors: *Chris, we hope you enjoy this special issue on space art (including discussions of Chesley Bonestell starting on pages 6, 18, and 40) and its power to inspire and engage!*

Errata

In the January 2022 issue, we wrote that M55 (#82 on the list) was approaching us at "more than 100 miles per second (62 kilometers per second)." While 100 miles per second is the correct figure, the conversion to kilometers should be 160 kilometers per second.

In the image accompanying entry No. 48 on our January 2022 list of "Top 100 cosmic objects you must see," Markarian 205 is the bright object directly below the larger NGC 4313, not the target indicated by the arrow to its upper right.

In the February 2022 issue, the article "Fourth time's the charm" stated that the mass of the MACS J0138 galaxy cluster was "about a billion times that of the Sun." The cluster is in fact about a hundred trillion times the mass of the Sun.

A tilted world

I enjoyed "Cosmic Tour of the Planets" (December 2021), as it brought together various facts for easy comparison. But I was left a bit confused by the statements that Uranus' rotation is retrograde and its axis is tilted at 100 degrees. If both are true, couldn't I say with equal validity that no, the rotation is normal and the axis is tilted at 80 degrees? After all, there's no big N on one of the poles. And with Venus you say the rotation is retrograde but you don't say its axis is tilted at 180 degrees. Is this difference something real or semantics? **—Tom Wright,** San Diego, CA

Senior Associate Editor Alison Klesman responds: *That's a great question and does involve perhaps a bit of semantics: According to the official IAU definition, a planet's north pole (with respect to rotation) is the pole that sits north of the ecliptic. So, regardless of a planet's tilt, which can range from 0 to 180 and is determined by the right-hand rule, whichever pole is above the solar system's plane is the north rotational pole. If you were to look downward from the ecliptic at Uranus and Venus, based on this definition of their north pole and direction of rotation, both are rotating retrograde.*

"Cosmic Tour of the Planets," December 2021

TAKING HUMANITY TO THE STARS

Space art celebrates the past and envisions the future of cosmic exploration.

BY ALDO SPADONI

FOR AS LONG AS the dream of human spaceflight has existed, artists have been inspired to imagine and depict what such amazing journeys might look like. Before the age of modern photography, explorers were frequently accompanied by artists who created drawings and paintings of the unknown regions of the world to delight and inspire the public. This trend has continued as the space artists of today work with the global astronomy community to create inspirational visions of space exploration.

The modern era of space art began after World War II. Rapid progress in aviation, rocketry, atomic energy, and other technical advances made the development of spacecraft seem tangible. The U.S. emerged from WWII as a global superpower with enormous technical and industrial capacity. At the same time, science fiction stories focused on space adventures increased in popularity. Human spaceflight appeared to be just around the corner and space artists such as Chesley Bonestell (1888–1986) played an important role in making space travel appear real to the public. Bonestell's paintings exhibited a startling realism, making it easy to believe they represented an actual glimpse of humanity's spacefaring future.

Following the Soviet Union's launch of Sputnik in 1957, space art was strongly influenced by humanity's rapidly expanding efforts to explore space. The space race between the USSR and the U.S. culminated in the Apollo lunar landings from 1969 to 1972. During this exciting time, there appeared to be no limits to what humanity could accomplish in space. Seeing the success of the American space program, aerospace companies commissioned space art to promote bold visions of robust human exploration throughout the solar system.

But after the Moon landings, the pace of human space exploration slowed

ADRIANNA ALLEN

Emanation

Digital

The Moon. Mars. Jupiter. Saturn. Each world calls to us, begging us to explore the wonders that await. We will become cosmic explorers. But even as we extend our reach, we will always hold our origin close to our hearts.

MOON SURFACE: PAVEL CHAGOCHKIN/DREAMSTIME

considerably. In the 1980s, NASA's space shuttle flew for the first time, enabling limited human activity in space to crewed operations in low Earth orbit (LEO). These efforts ultimately led to the establishment of the International Space Station (ISS).

While the prospects for human exploration of the solar system dwindled, robotic missions expanded dramatically, with an astounding record of success. By 2022, every planet in the solar system had been visited, as well as numerous asteroids, comets, and Kuiper Belt objects. And several robot spacecraft are outbound into the depths of interstellar space, bearing messages from humanity.

Although humans have not ventured beyond LEO since the Apollo Moon landings, space visionaries persevered, aided by space artists who continued to create compelling visions of robust human spacefaring.

Today, we are experiencing an exciting Second Golden Age of space exploration with the rise of commercial spaceflight operations by a variety of private companies. NASA is now developing new launch vehicles and spacecraft for human space operations beyond LEO. Ambitious plans are being created for human exploration on the Moon, Mars, and beyond. The road ahead remains challenging, but humanity is moving forward, and space artists are helping to show the way.

Space art encompasses a wide variety of subject matter, but a significant portion of it focuses on envisioning how humans travel, explore, live, and work in space. This kind of art usually contains depictions of spacecraft, astronauts, satellites, space stations, habitats, and the associated hardware involved in human spacefaring.

While there are a variety of artistic styles that can be employed, many of the artists attracted to the demanding world of space exploration are realists. In other words, their depictions are representational and realistic. Many space artists choose to adopt a traditional "painterly" style, where the brushstrokes are quite visible, yet the resulting image is immediately recognizable. Furthermore, realists generally aim to convey their subject matter in a compelling and believable manner. Photographic realism is merely one method of attaining this goal, while other artists might choose a much more abstract approach.

The realist space artist must master a variety of skills to create convincing renditions of human space exploration. These skills include perspective and mechanical drawing techniques, a grasp of basic engineering principles, and the ability to create effective astronomical backdrops for the scene. All these are combined using artistic insight to create art that is aesthetically pleasing as well as technically plausible.

The use of traditional media is alive and well in the world of space art. Artists use a wide array of tools such as pencils, pens, markers, and paint to create their visions. However, a significant portion of space art has moved into the digital realm, especially for those artists who specialize in depicting hardware. Since real-world

MARILYNN FLYNN

Shamshu Sojourn

Digital

A couple hiking in the Shamshu region of Jupiter's moon Io watches as a lava geyser sputters to life beyond the distant hills. Amazing vistas of cliffs and jumbled terrain colored by sulfur compounds stretch before the space tourists, who wear futuristic radiation-proof suits.

hardware is now designed using 3D computer-aided models and virtual reality tools, it's only natural that artists should follow suit. The rapid development and commercial availability of those powerful tools has enabled many new possibilities for space artists. Even when creating artwork using traditional hand-painting techniques, 3D modeling and rendering can provide excellent reference imagery to ensure that the scene perspective and lighting are correct for a given view.

Space art is frequently used to accurately document significant events in aerospace history. It is extensively used by the global aerospace industry to illustrate and explain complex spacecraft design and mission proposals. Compelling art influences investors and the public and helps fund the project. After all, the best space art always manages to convey a sense of wonder and the impending adventure that awaits humanity as we set sail upon the vast ocean of space.

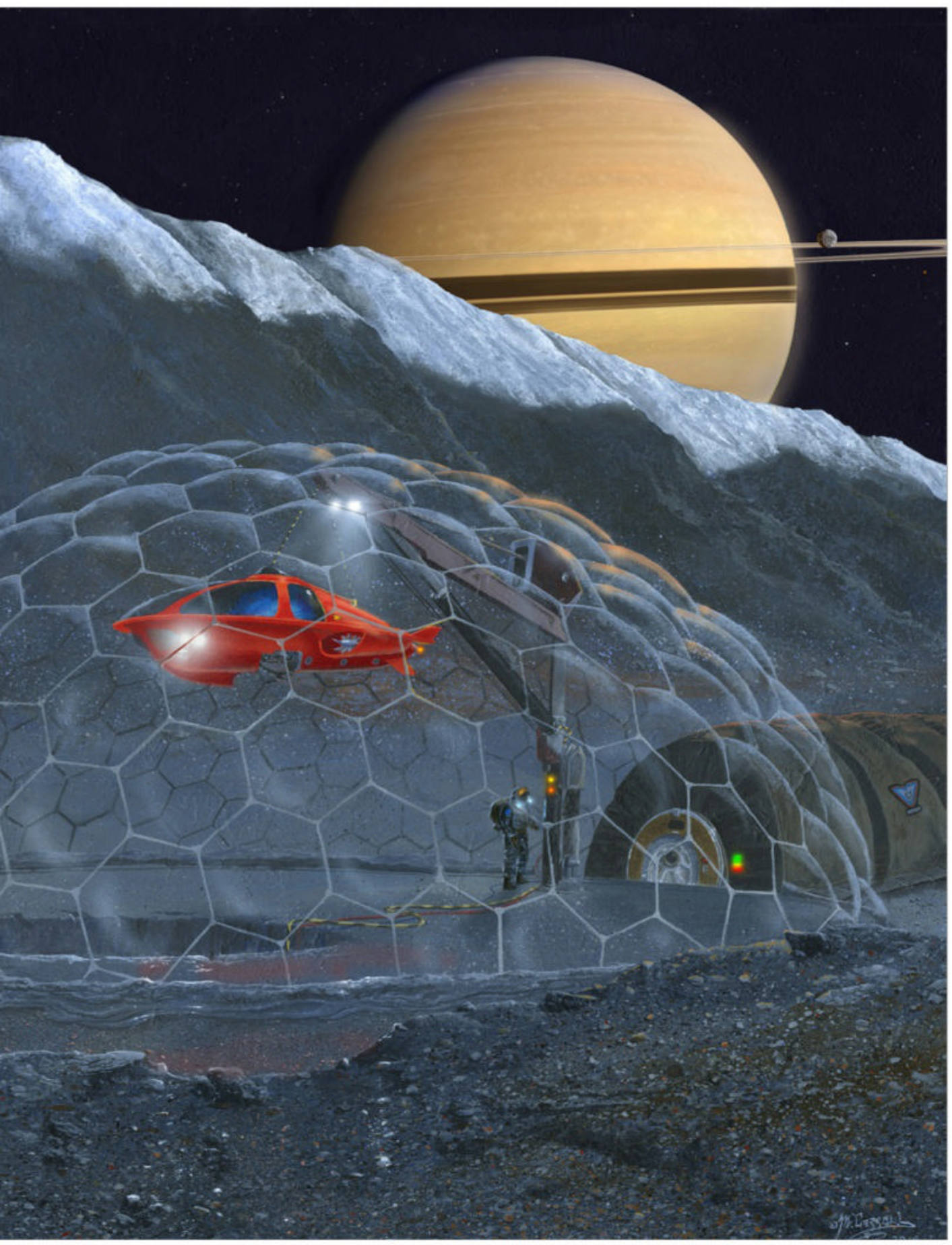
Aldo Spadoni *is an accomplished illustrator, concept designer, and aerospace engineer-futurist. He is also president and a fellow of the International Association of Astronomical Artists (IAAA).*

MICHAEL CARROLL

Exploring Enceladus

Acrylic/digital

Future explorers drill through the ice to explore the global seas of Enceladus. Here, a pressure dome keeps water from erupting into the vacuum of space as an astronaut digs for the precious resource.



CHRIS CALLE

Gemini IV Spacewalk

Oil

Astronaut Ed White performs America's first spacewalk, secured to the spacecraft with an umbilical line. Shaved samples from some of the pieces of silver that astronaut Jim McDivitt carried with him on the Gemini 4 Mission have been mixed into the oil paint for White's space suit and cord.

"This is a great painting … of my view of Ed White set against the perfect, beautiful blue Earth. [White] was having so much fun he didn't want to get back in the spacecraft!"

— Jim McDivitt, Gemini 4 Commander

PAT RAWLINGS
Family

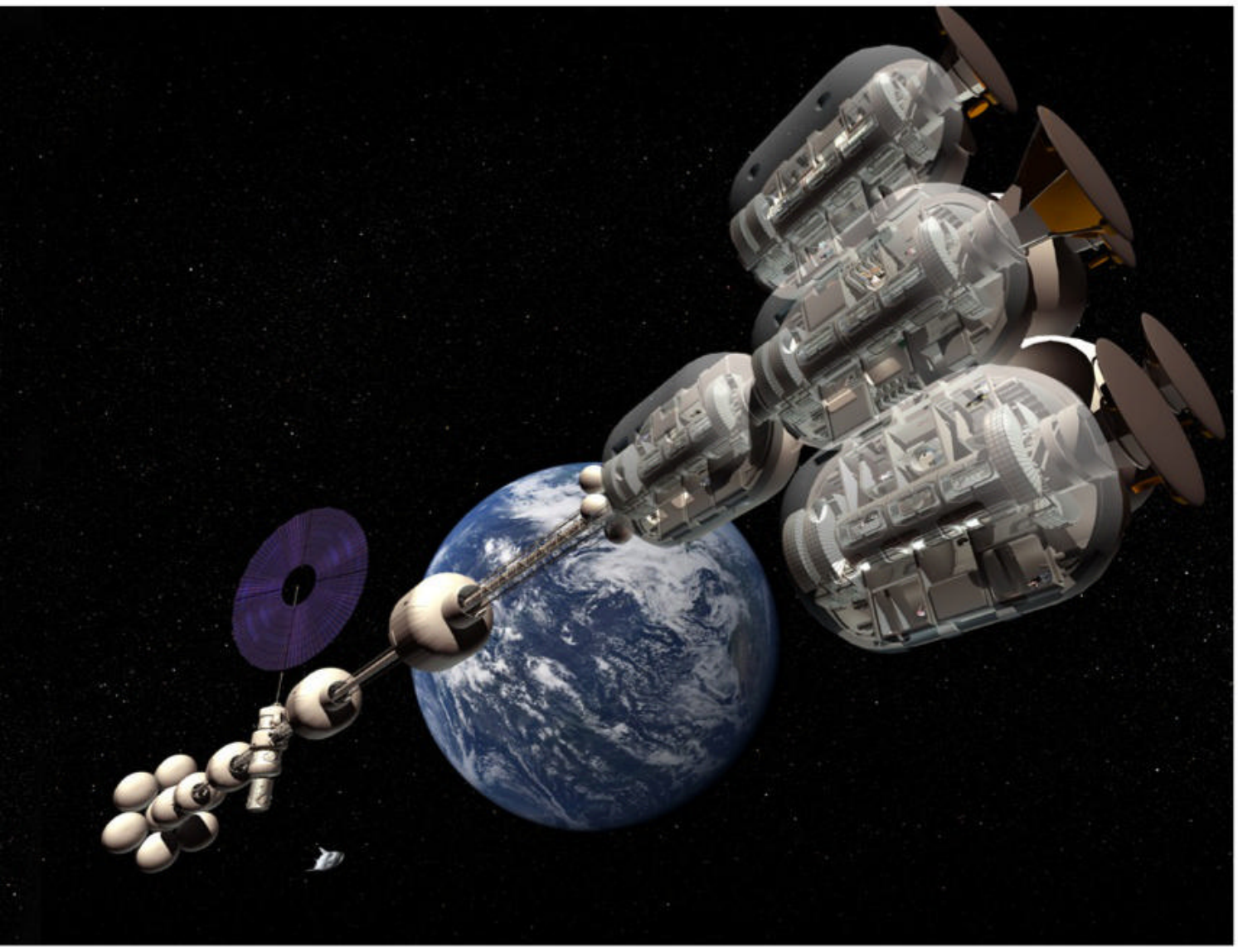
Acrylic

Sojourner, the Mars Pathfinder rover named after former slave and abolitionist Sojourner Truth, receives a visit by a descendant of its namesake, many years after its mission's end.

MARK MAXWELL
TETHERHAB 2021

Digital

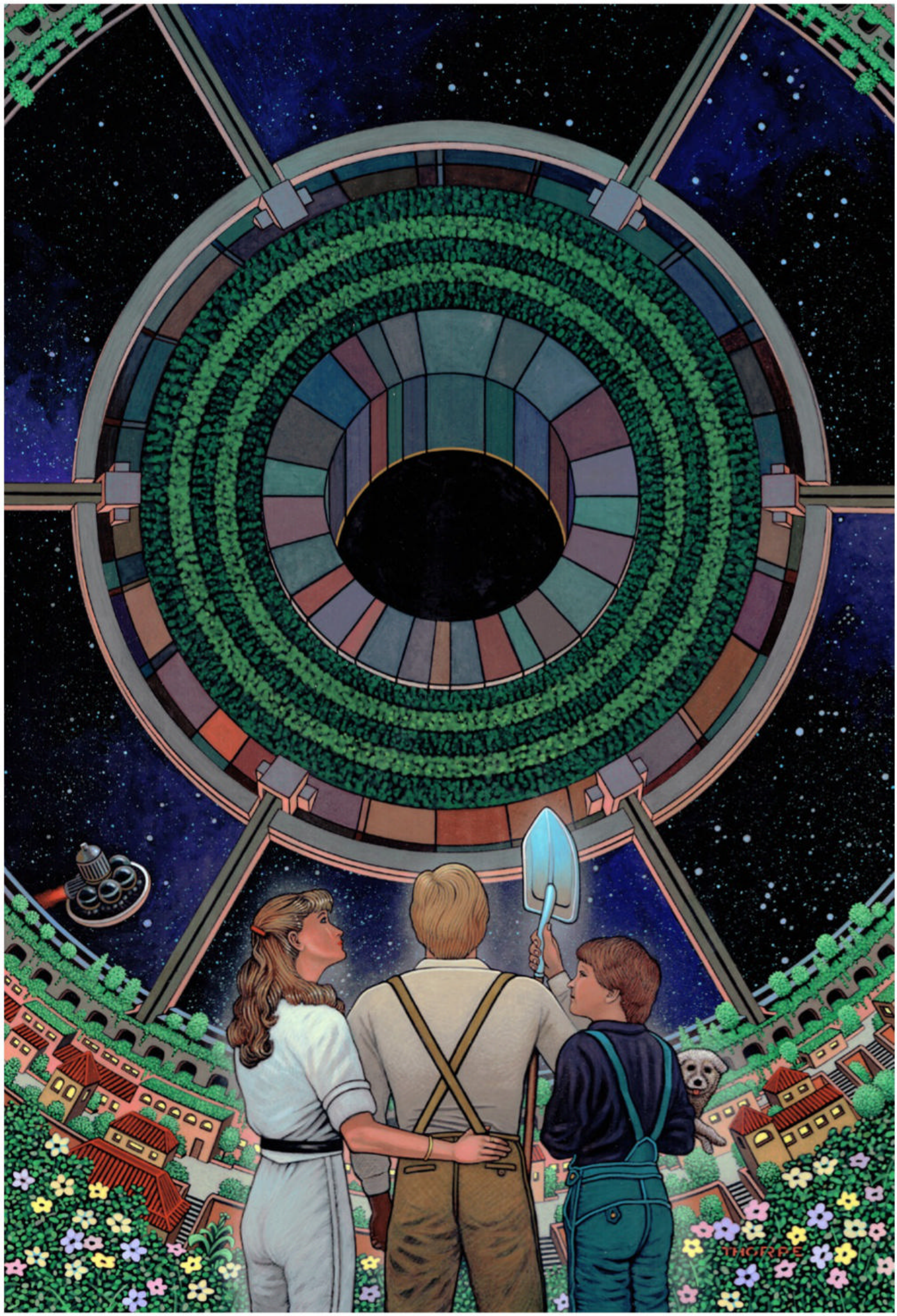
A rotating tethered habitat orbits above an Earth-like world. Using solar panels for power, the station is capable of housing 100 people in a variable-gravity environment. A spacecraft at lower left is returning from an exploratory mission to the surface of the planet.



PETER THORPE
The High Frontier

Acrylic

A space colony family gazes at farmland in the end cap of an O'Neill cylinder — two counter-rotating cylinders. The windows around the farmland show space outside, while community buildings sit in the foreground.


THORPE

STEVEN HOBBS

Mars Station

Digital

An astronaut walks between two stations on the martian moon Phobos. Meanwhile, a spacecraft leaves the base for a Mars surface mission.

JUSMENA FONSECA

Sunset on Mars

Oil

Newly arrived Terrans settle down to view their first sunset on Mars. The Sun is a welcome reminder of home as it breaks through the dusty sky, revealing a blue-tinged sunset.

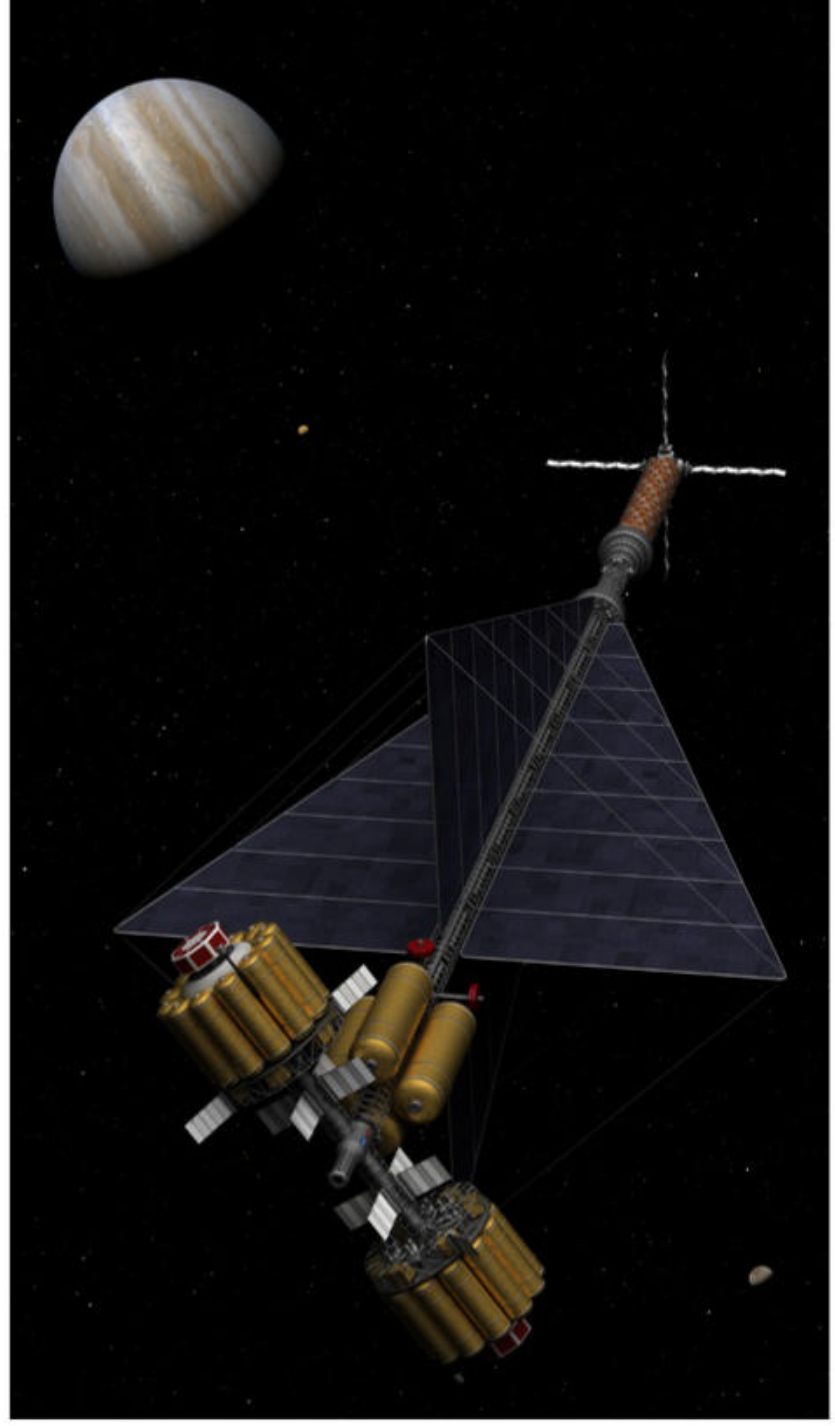
> "It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."
>
> **— Robert H. Goddard,**
>
> physicist and rocketry pioneer

DOUG FORREST

Foot of the Ladder

Graphite pencil

On July 20, 1969, at 2:55 A.M. UTC, Neil Armstrong reported, "I'm at the foot of the ladder." He is once again on the ladder in this artist's concept. In just a few seconds' time, Armstrong will become the first human to set foot on the Moon.



NICK STEVENS

HOPE VASIMR at Jupiter

Digital

HOPE (Human Outer Planet Exploration) is a design for a vehicle that could take humanity to the Jupiter system. The crew live between the craft's rotating liquid hydrogen tanks, which provide radiation shielding.

PRISCILLA THOMAS

Defiance

Oil

First debuting in 1966, the Soyuz rockets have become the most frequently used launch vehicles in the world. The mighty rocket leaves Earth for space in another bone-shaking defiance of gravity.

MARK PESTANA

Artemis, Sister of Apollo

Acrylic

As she collects lunar samples near a conceptual lander, the next human to step on the Moon pioneers a new phase of exploration. A half-century after the Apollo era of heavy, cumbersome spacesuits, new materials and engineering have enabled more flexibility, endurance, and comfort.


Mark Pestana
© 2021

PAINTING THE

Astronomers deal with numbers and measurements, but artists can show us the landscapes the data describe.

BY WILLIAM K. HARTMANN

PAINTERS HAVE PLAYED A SIGNIFICANT but underappreciated role in our exploration of the worlds in our solar system.

Scientists tend to specialize in narrow aspects of reality — spectroscopy, photos, petrology — all represented in terms of numerical measurements. But what do these numbers mean in terms of the human experience? It is artists who synthesize those results to visualize what each world is truly like.

In the early 1900s, the French artist and astronomy popularizer Lucien Rudaux (1874–1947) published numerous paintings showing surface environments on our neighbor worlds, based on then-current scientific knowledge. His 1937 book *Sur les Autres Mondes* (*On Other Worlds*) included many such paintings, some reproduced in color. And thanks to the efforts of a number of enthusiasts including myself, Rudaux's book was republished in 1990 in a facsimile edition by the original Paris publisher, Larousse.

Rudaux's book enthused an American artist, Chesley Bonestell (1888–1986), who was a leading special-effects artist in Hollywood, having painted backdrops in famous films such as *Citizen Kane*. In 1944, the popular weekly *LIFE* magazine published a series of paintings by Bonestell, showing the planet Saturn as seen from its various satellites.

Saturn's largest moon, Titan — which is larger than the planet Mercury — presented an interesting challenge. Astronomer Gerard Kuiper had recently confirmed earlier suspicions that Titan had a substantial atmosphere. (It is, in fact, the only moon in the solar system to have one.) Bonestell saw the opportunity to paint a moonscape without a black sky and

DAVID A. HARDY

Comet Lander

Digital

An imaginary robotic lander eclipses the Sun as it fires retro-rockets in preparation for touching down on a comet. The comet's surface, though icy, appears dark due to a widespread coating of hydrocarbons. The image was designed for the 2004 book *Futures: 50 Years in Space* (Harper Design), by Hardy and Sir Patrick Moore.

SOLAR SYSTEM

produced a famous painting showing Saturn in a blue sky over an icy landscape.

But the view from Titan continued to challenge scientists as well as artists. Decades of scientific progress following Bonestell's painting indicated that Titan's atmosphere produces not a clear blue sky, but a cloudy haze so thick that Saturn might be rarely, if ever, visible from the surface.

This story is just one example of the importance of astronomical art. Scientists publish their work in peer-reviewed journals, but astronomical realist painters translate the results to show what distant worlds would look like if we could be there.

Here's another example: In 1949, Bonestell illustrated a world-changing book, *The Conquest of Space*, with text by science popularizer Willy Ley. The book's paintings included new landscapes on various planets, created based on consultations with scientists during preparation of the book. Its cover showed a sleek, silver rocket and astronauts on the Moon. (As astronomical artist and historian Ron Miller has said, "That's the way rockets were supposed to look!") Many of the engineers and scientists who put the Apollo astronauts on the Moon were inspired by that book as teenagers. The great science-fiction author Jules Verne is often quoted as writing, "Anything one man can imagine, other men can make real." Bonestell's paintings showed the dream and the Apollo engineers made it a reality.

Ludek Pesek (1919–1999) was another pioneer of astronomical art. His work is widely known in Europe. The Czech artist was vacationing in Switzerland in 1968 when the Soviet Union invaded Czechoslovakia, prompting him to remain in Switzerland for the rest of his life. His paintings, while mostly realistic, sometimes included touches of whimsy. I was fortunate to visit Pesek and his wife in Switzerland, and in their home I noted a view of a lunar hillside showing a large rock that had rolled toward the viewer, leaving a visible track behind it — but the boulder appeared to have been stopped in the foreground by a tiny flower.

The artistic movement started by Rudaux, Bonestell, and Pesek might be called astronomical realism. Each painting (and this includes terrestrial landscape paintings, since Earth is a planet, too) challenges the artist to depict reality — not as it is expected or as artists would like it to be, but as it actually exists.

This triangular relationship of nature, art, and science is well demonstrated by Earth's blue sky. Its hue is explained through Rayleigh scattering — the preferential scattering of blue light by microscopic particles in the atmosphere, discovered by English scientist Lord Rayleigh in the late 1800s. But nearly 400 years earlier, the

ERIKA A. MCGINNIS

Mauna Kea Observatory

Acrylic

Two of the many telescopes situated atop Mauna Kea in Hawaii sit beneath a beautiful sunset as the astronomers stationed within anticipate clear skies for spectacular viewing of the universe. This painting is the third in a series of images of U.S. observatories and part of a larger project the artist is currently working on.

GARRY L. HARWOOD

Lunar Rille Formation

Oil

Fluid, high-temperature lava explosively erupts from a system of vents on the Moon's surface some 2 billion years ago, while a young Earth eclipses the Sun in the lunar sky. Such events carved out the sinuous rilles, or lava channels, we observe today.

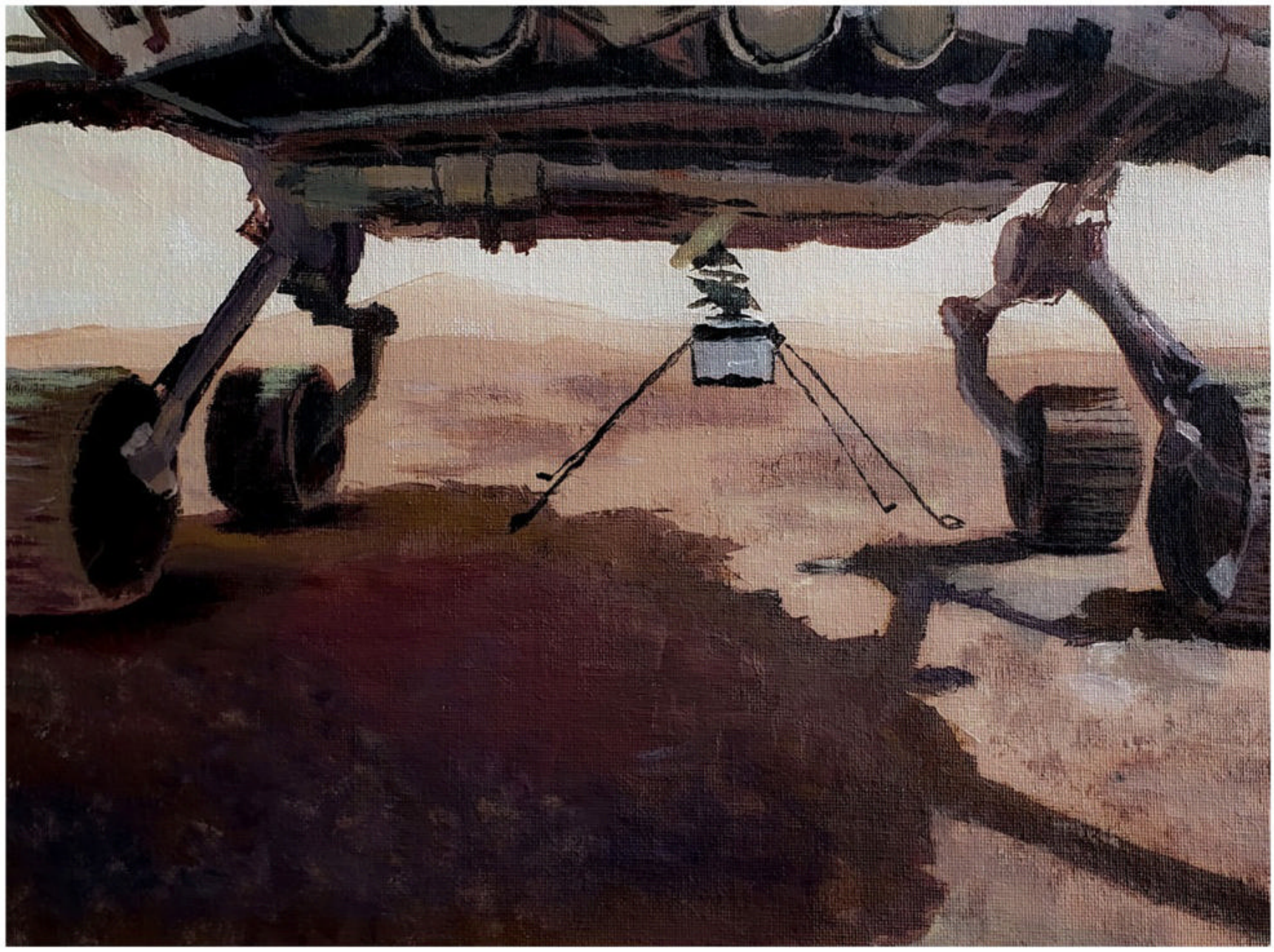
painter and scientist Leonardo da Vinci pointed out in a booklet on painting that a building or mountain in the distance has paler shadows and bluer color than one in the foreground. He concluded correctly that sunlit air adds blue light. The greater the distance, the more blue light appears. Rayleigh worked out the physics, allowing predictions about the blue light, but long before he did, da Vinci had described the human perception of the effect, which painters call atmospheric perspective.

Each planet offers a unique challenge. Mars might seem easy to paint because of the abundant imagery from landers and rovers, as well as the presence of similar landscapes on Earth. However, determining the actual colors that would be perceived by a human on the surface has been a problem from the start. As I witnessed while reporting for *Astronomy* in 1976, NASA's initial press release landscape from the first successful martian lander, Viking 1, showed — as then expected — a blue sky. But after some hours, the Viking imaging team realized that reddish colors dominated not only the landscape but also the sky. The problem arose from incorrectly balancing blue filter and red filter signals from the lander's camera.

Later landers and rovers have suggested the martian sky color varies with the dust content in the air. I've witnessed a similar shift in Arizona, from blue to tan, during dust storms. To confuse matters further, some martian images are deliberately altered toward bluer colors, so that geologists can get a sense of martian rock formations in lighting more like that on Earth, under our blue sky. So, the internet is full of Mars images with different color balances, including attempted true-color images. What does Mars really look like to a human visitor? We have yet to find out.

One lesson we should take away from all this is not to throw out older paintings because they might be scientifically wrong. Instead, they preserve an important record of what we as human beings knew about our solar system at the time they were painted. And what we have learned along the way is that when it comes to exploring our solar system, painters and scientists have a fascinating and productive relationship!

William K. Hartmann *is a planetary scientist, artist, and writer. With Donald R. Davis, he originated the current hypothesis that the Moon formed from debris of a giant impact on primordial Earth.*



DANIEL DAHAN

Mother and Child

Acrylic

Shortly after arriving on the Red Planet, NASA's newest Mars rover, Perseverance, set down the tiny robotic helicopter Ingenuity. Mars Exploration Rover project manager John Callas described this painting, which depicts that moment, as showing the maternal relationship between the rover and its companion. The artist remains awestruck by the surprisingly heartfelt emotional undertones that connect these two amazing machines.

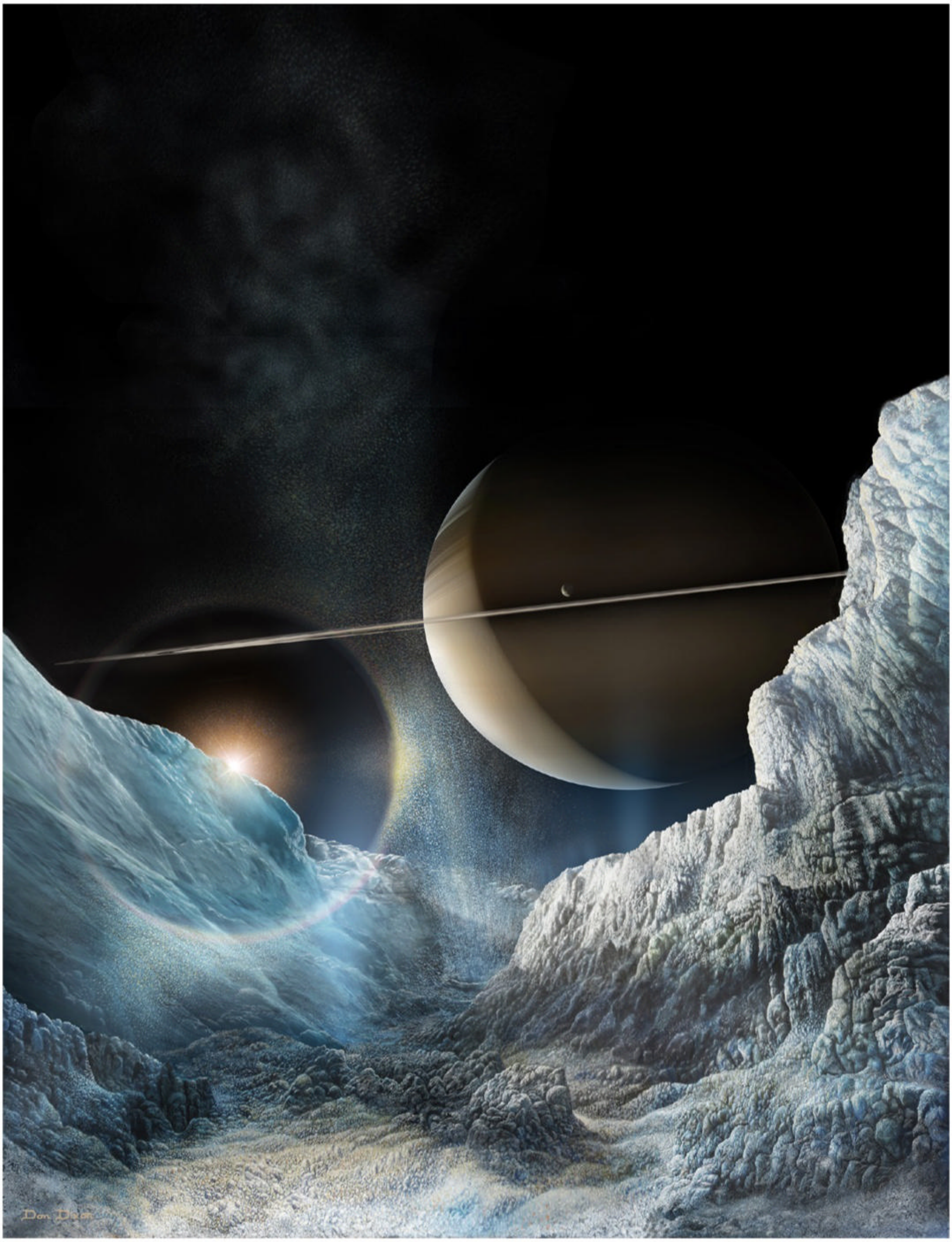
DON DIXON

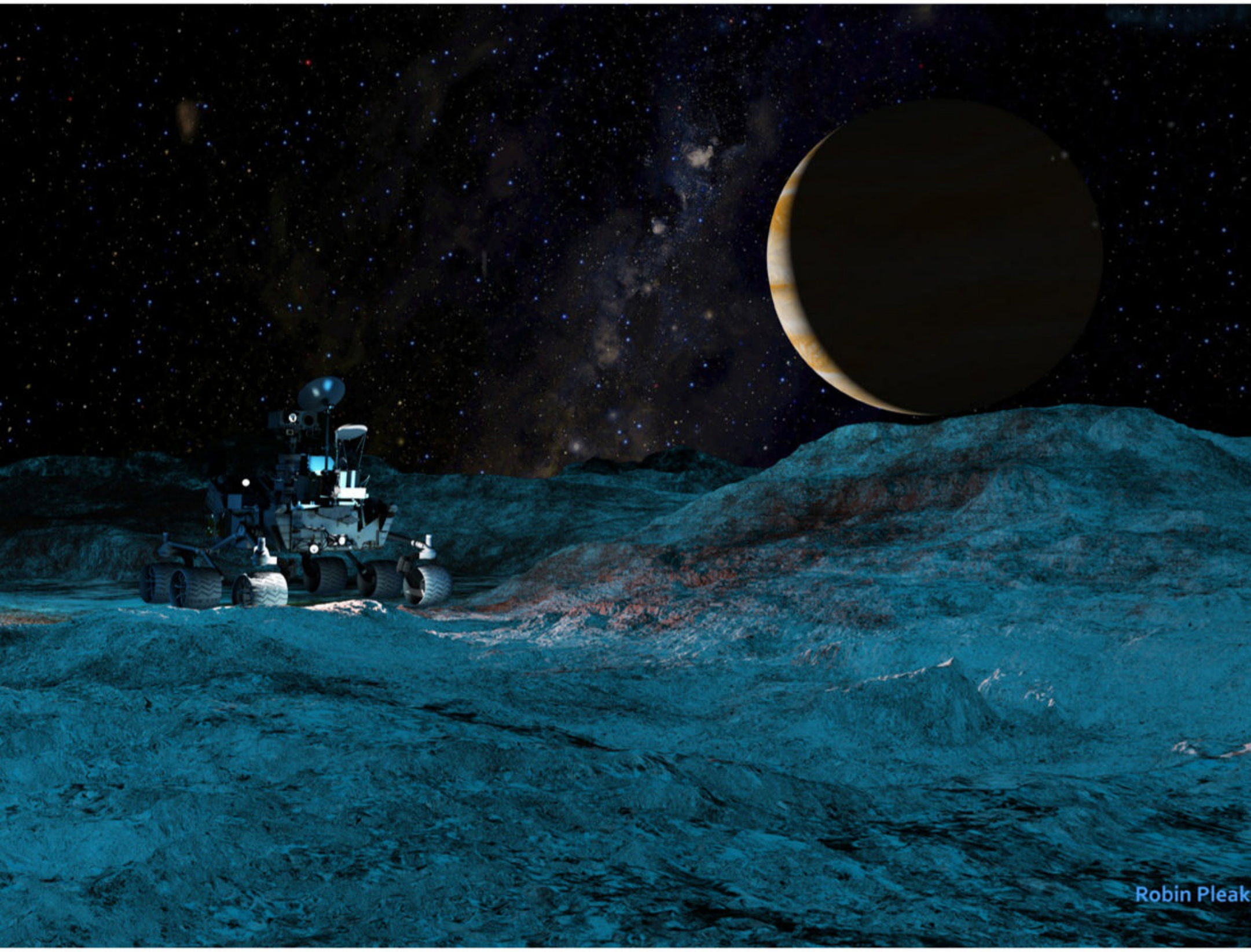
Enceladus

Oil/digital

Jets of water erupt into space and fall as snow in this view from inside one of the famous tiger-stripe features near the south pole of Enceladus. Fellow satellite Mimas transits Saturn in the background. The image shows the complex features that might form when ice particles launched at high velocity rain down in a low-gravity environment.

It is artists who synthesize scientific results to visualize what each world is truly like.





ROBIN PLEAK

Europa Glow

Digital

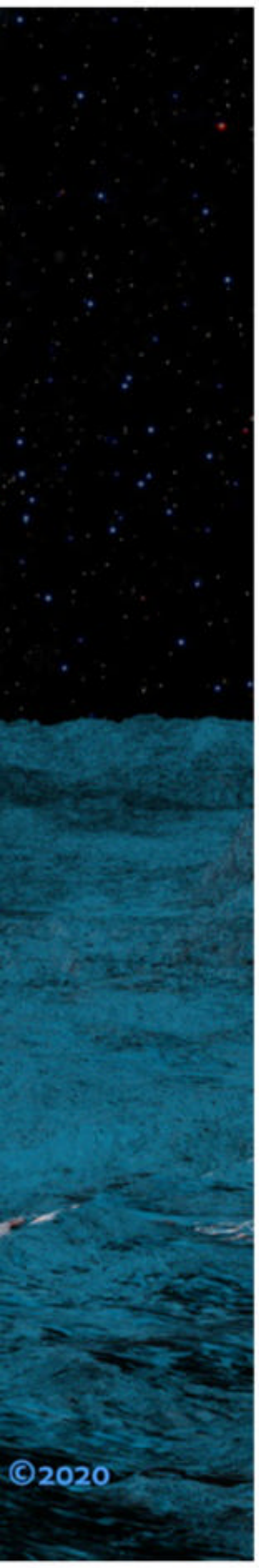
A small robotic rover travels the trackless wastes of Europa, bathed in the dim glow of ice and snow that have been excited by intense radiation from nearby Jupiter. The radiation will severely limit the functional lifetime of any craft sent to explore the icy moon, as energetic particles bombard onboard computers and other delicate electronics, quickly degrading them.

MARILYNN FLYNN

Titan's Southern Summer

Digital

A cloudburst of methane rain floods a river as it carves a canyon through layers of reddish hydrocarbon-tainted water ice on Titan. Astronomers have observed convective clouds in the moon's southern hemisphere during its summer; rainfall from such clouds could be substantial. Meanwhile, images from Cassini reveal flowing river channels of liquid methane and ethane feeding lakes. This moon is so cold that water ice plays the role of solid rock.


©2020

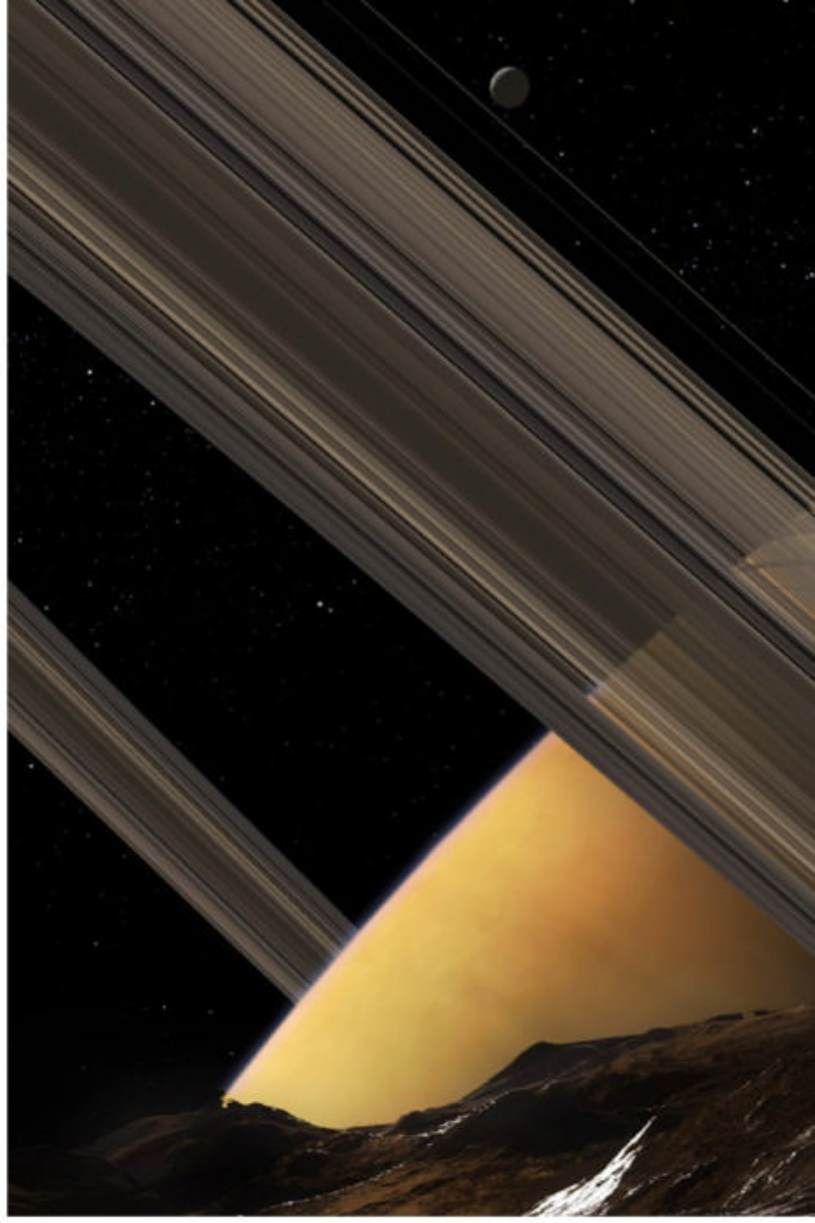

FLYNN '13

STEVEN HOBBS

Saturn From Passing Comet

Digital

Saturn dominates the view of an imaginary observer standing on the surface of a dormant comet as it passes by the mighty ringed planet. The close flyby will impart a gravity boost that will send the small world into the inner solar system. And as it nears the Sun, it will grow a coma and tail, sprouting into an active comet for earthbound skywatchers to enjoy.

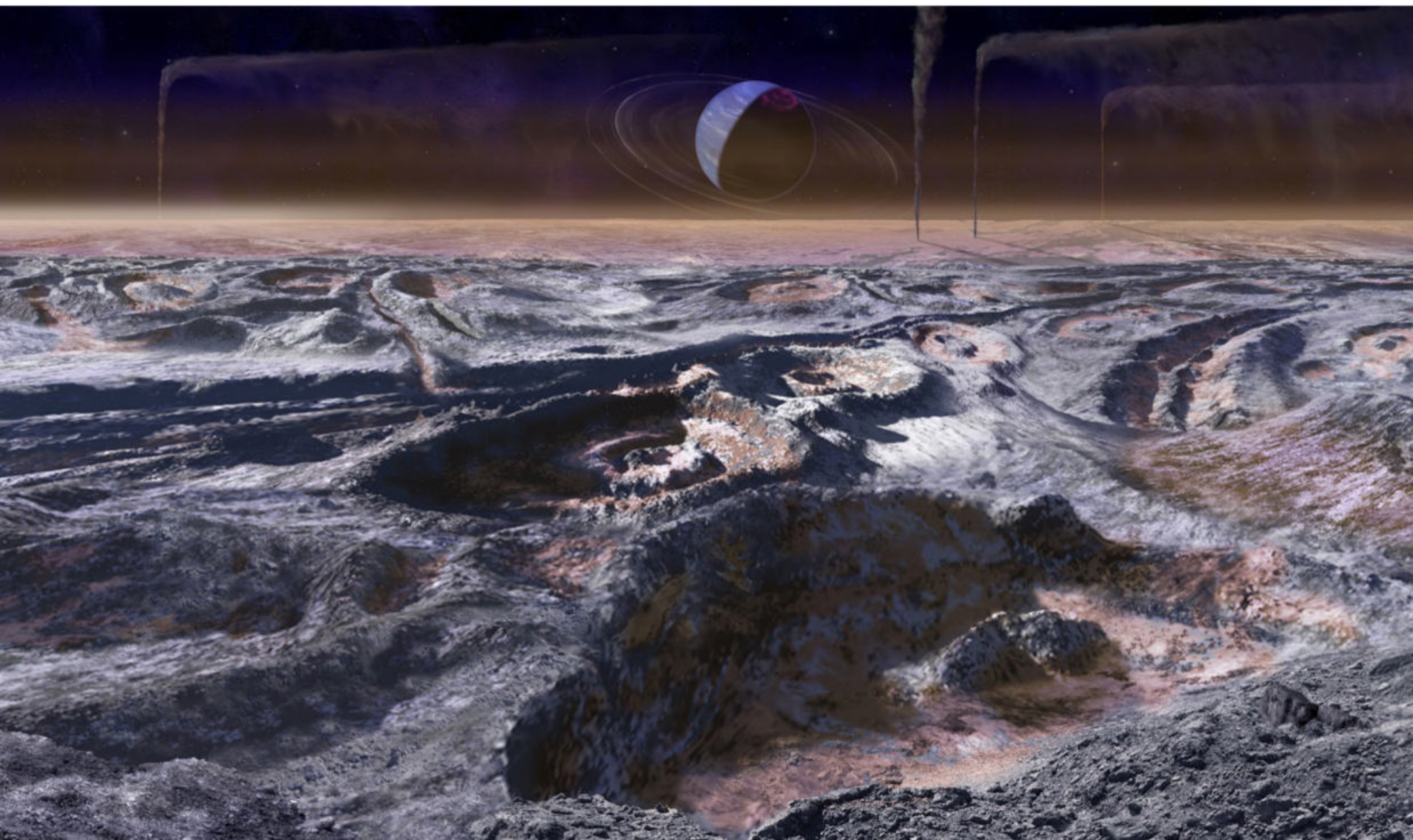


MICHAEL CARROLL

Triton's Cantaloupe Terrain

Acrylic/digital

Triton's mysterious cantaloupe terrain is unique in our solar system. Its melon-rind appearance comes from depressions called cavi. This region sits at the edge of Triton's pink nitrogen-ice polar cap and is thought to result from a combination of erosion, sublimation, and internal forces.



Astronomical realism challenges the artist to depict reality — not as it is expected or as artists would like it to be, but as it actually exists.

MICHAEL LENTZ

DAVINCI on Venus

Digital

NASA's round DAVINCI probe sits on the surface of Venus, its mission of sampling the planet's clouds from top to bottom complete. DAVINCI is currently under development for launch in 2029. Its descent will mark the first U.S. mission in four decades to enter the atmosphere of Earth's sister planet.

"I didn't know what other worlds looked like until I saw Bonestell's paintings."

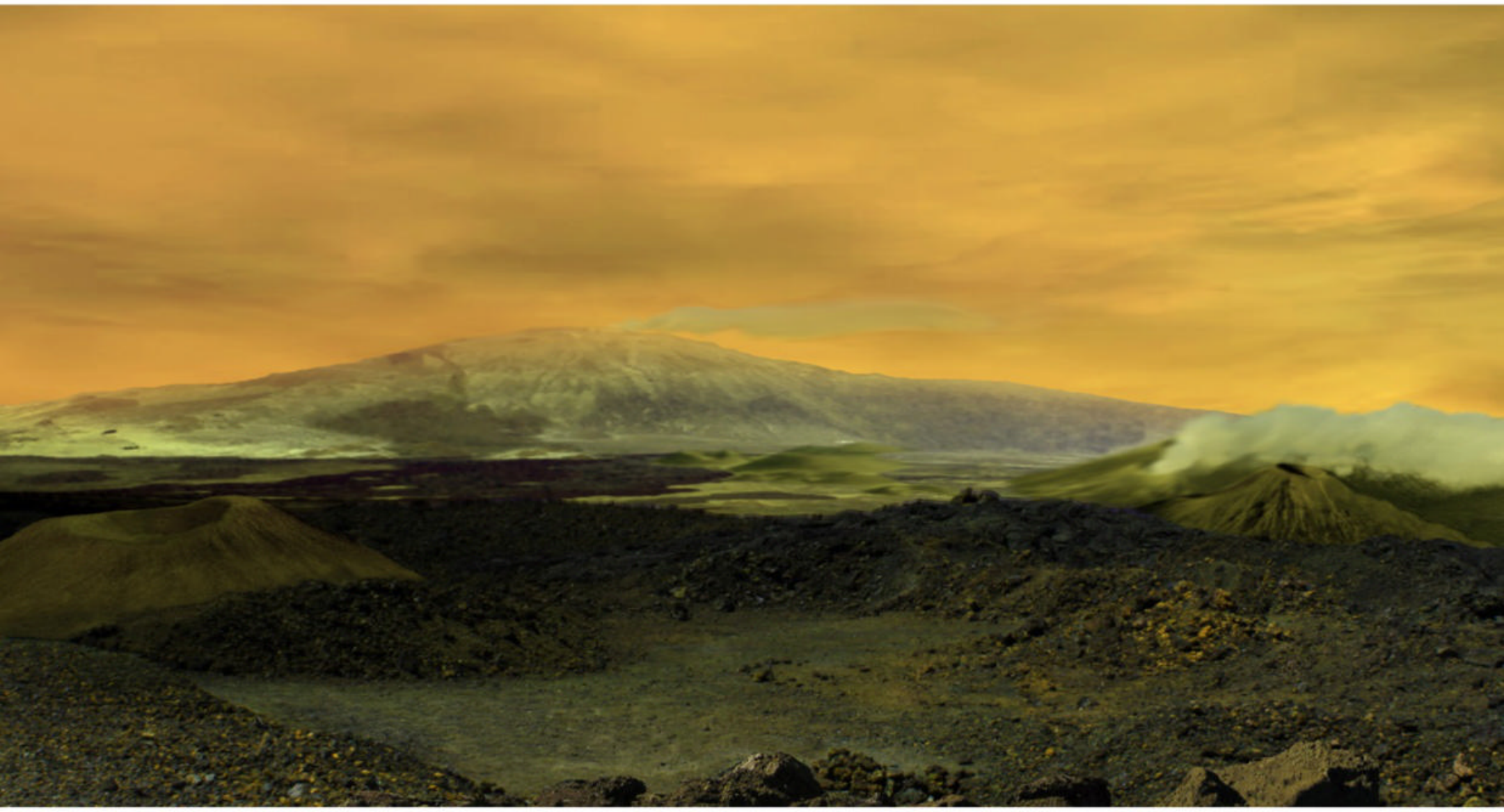
— **Carl Sagan,** astronomer and science popularizer

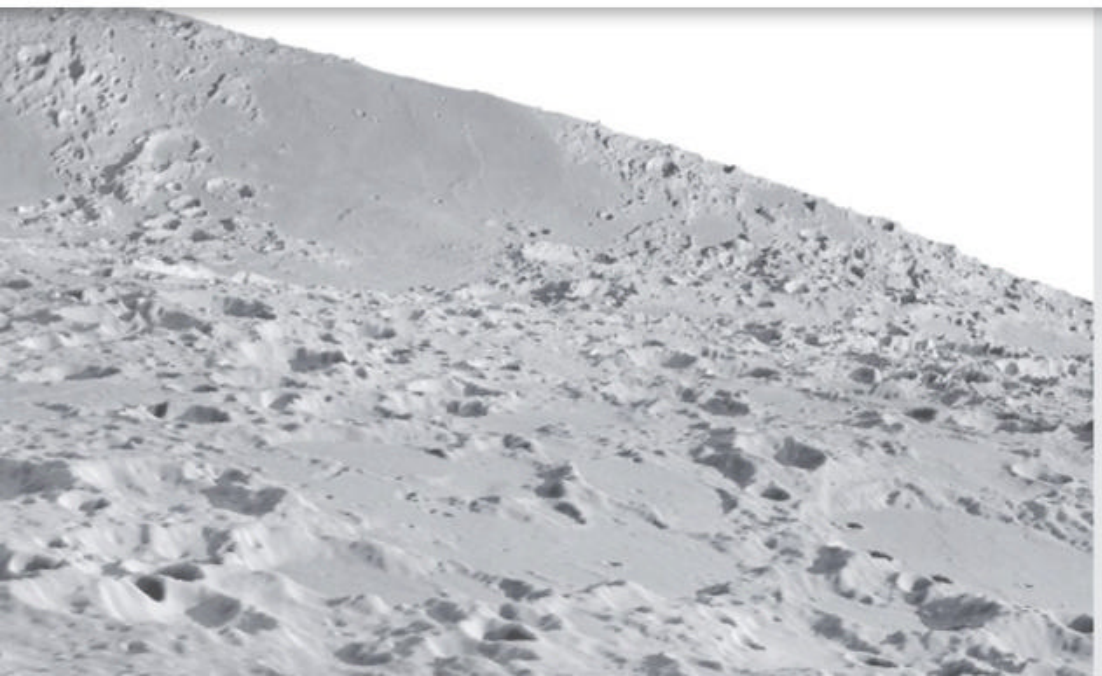
RON MILLER

After a Methane Rain on Titan

Digital

This scene shows the surface of Titan only moments after a methane rainfall has passed. Rivulets of liquid methane drain into methane streams that eventually lead to a larger methane sea. On Titan, the weather is driven by cycles of methane and ethane, much like the more familiar water cycle that occurs on Earth.



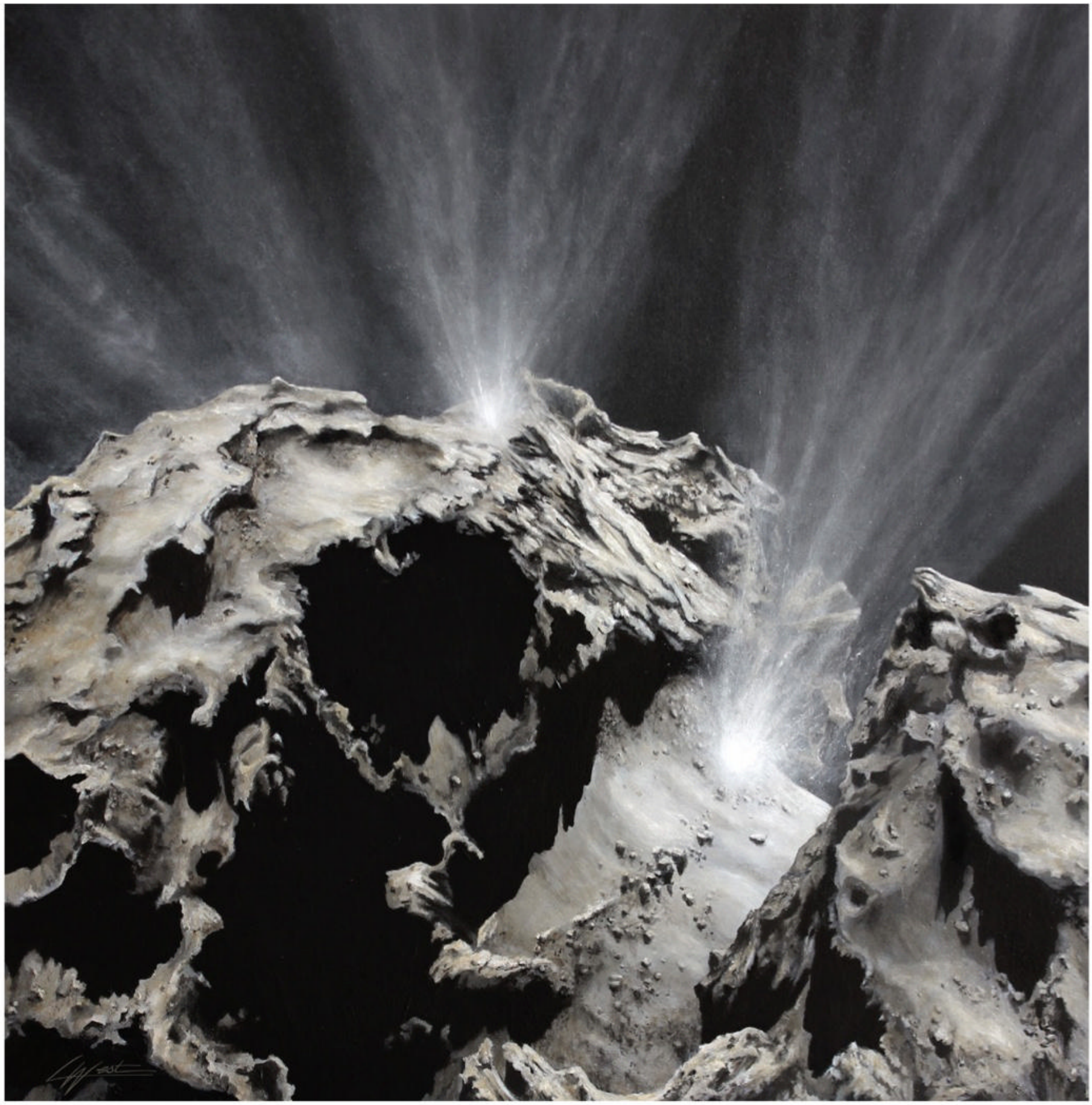


JON RAMER

Maat Mons

Digital

Maat Mons is the tallest volcano on Venus, topping out 26,250 feet (8,000 m) above Venus' mean surface level. This digital image shows it as an active volcano with ash rising from the summit, surrounded by lava flows. Steam eruptions are not possible on Venus, due to its surface temperature of 900 degrees Fahrenheit (475 degrees Celsius). Colors and lighting for this image were sourced from Soviet Venera images.



LUCY WEST

Waking Wanderer

Acrylic

Comet 67P/Churyumov–Gerasimenko's surface slowly wakes as it soars closer to the Sun, generating plumes of ice and dust and turning a cold space rock into an active comet.

THE SOLAR SYSTEM'S CHANGING LANDSCAPE AS IT APPEARS IN EARTH'S SKY.

BY MARTIN RATCLIFFE AND ALISTER LING

Predawn planetary sights

Bright Mars takes center stage amid the stars of Pisces and Cetus. ALAN DYER

JULY 2022

Continuing last month's spectacular array of planets in the morning sky, July offers many planetary delights to be savored, with all seven major planets on display. Catch Mercury early in the month, because it will soon hide behind the Sun. Venus is a dominant morning star, joined in the earlier morning hours by Mars, Jupiter, Saturn, Uranus, and Neptune — the latter two as binocular targets.

We will begin with a brief look at the array of planets on the morning of July 1 before moving to our traditional journey from evening to morning sky. Moving in order from the eastern horizon to high in the southern sky, you can spot Mercury, Venus, Uranus, Mars, Jupiter, Neptune, and Saturn in early July as dawn approaches. They stretch 118° along the ecliptic, through the constellations Taurus, Aries, Pisces, Aquarius, and Capricornus.

Mercury will drop quickly from the morning sky. Try to spot the magnitude –0.8 planet 30 minutes before sunrise on July 1, when it stands 6° above the eastern horizon from mid-northern latitudes. Even though Mercury brightens in the first few days of July, its angular separation from the Sun shrinks each day and it becomes harder to spot in growing twilight. By July 5, it is magnitude –1.1 and only 4° high 30 minutes before sunrise. It heads for superior conjunction on the 16th and then passes into the evening sky. More on Mercury shortly.

Venus stands 13° west of Mercury on July 1, nicely located north of 1st-magnitude Aldebaran in Taurus the Bull. Farther west along the ecliptic, Uranus lies in southern Aries, midway between Venus and Mars. Its magnitude 5.9 glow is hidden from direct view but reachable with 7x50 binoculars.

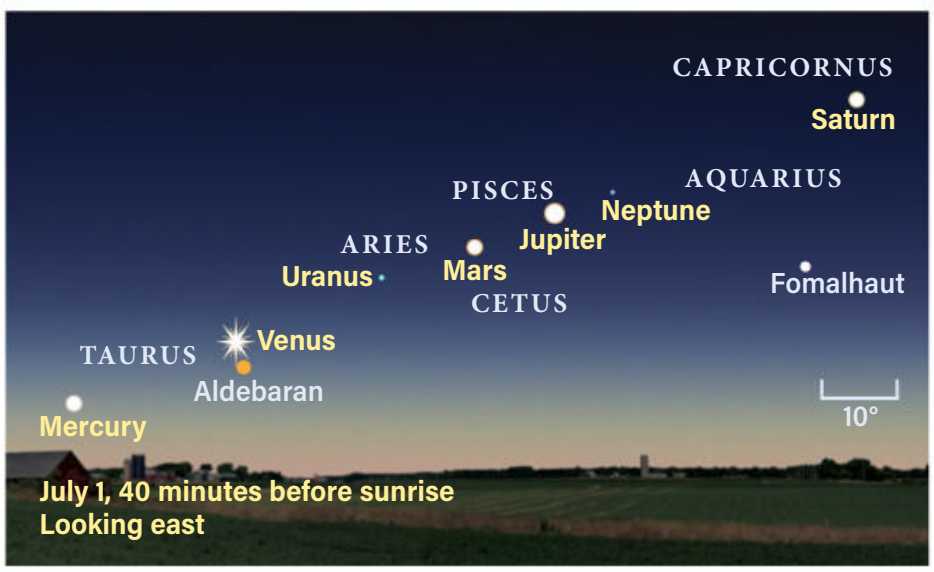
Mars stands just over 40° west of Venus and is 40° high in the east. It glows dull orange at magnitude 0.4. Less than 20° west of Mars, Jupiter is a brilliant magnitude –2.4. Another binocular planet, Neptune (magnitude 7.7) sits at the boundary of Pisces and Aquarius. Last is Saturn in the southern sky at magnitude 0.4.

Now let's return to the evening sky and progress until morning, watching each planet rise and checking out its details with a telescope.

First is **Mercury**, which earlier we found in the eastern sky before dawn. On the 16th, it passes around the far side of the Sun (superior conjunction) and moves into the evening sky.

You might finally spot Mercury July 25, when it is 10° east of the Sun and sets 40 minutes after our star. Try spotting it shining at magnitude –1.2 just 2° high, 25 minutes after sunset. Visibility doesn't greatly improve due to the shallow angle of the ecliptic to the western horizon this time of year. A favorable opportunity

Early gathering



July opens with an array of planets spread across the morning sky. Note that Uranus and Neptune, while shown here, will require binoculars or a telescope to spot. ALL ILLUSTRATIONS: *ASTRONOMY*: ROEN KELLY

OBSERVING HIGHLIGHT

VENUS passes just 24' north of the famous supernova remnant **M1** on July 13.

does occur July 29, when Mercury stands 2.7° below the crescent Moon. Find the Moon by 8:30 P.M. local time and search for Mercury slightly below and to its left.

On the last day of July, try to spot Regulus, Leo's brightest star, in the western sky. Mercury glows 5° to its lower right. Begin around 8:40 P.M. local time — you have about 20 minutes before the pair descends into the evening haze.

Saturn is next to appear, rising in the east just before 11 P.M. local time on July 1. It's approaching opposition and moving west (retrograde) against the background stars. Now is a great time to view the ringed planet. During the month, it brightens to magnitude 0.3 and remains less than 2° from Deneb Algedi, a 3rd-magnitude star in northeastern Capricornus. You'll find Saturn 6° northeast of a waning gibbous Moon late on the 15th.

Saturn offers a spectacular view through any telescope. Its ring system is visible with even a small scope, effectively doubling the 18" size of the planet's disk. The rings have narrowed since last summer, now tilted by just under 13° to our line of sight. This apparent tilt will increase a few degrees through the fall due to the orientation of Earth's orbital path

— *Continued on page 38*

RISING MOON | A top-down view

Brianchon and Pascal

This month, we get a peek over the top of Luna's head.
NASA'S SCIENTIFIC VISUALIZATION STUDIO. INSET: NASA/GSFC/ASU

CRATERS AT THE FRINGE become easy to enjoy when the Moon reaches its lowest high. Tucked against the northern limb on the west side of the pole lie Brianchon, Pascal, Sylvester, and Cremona.

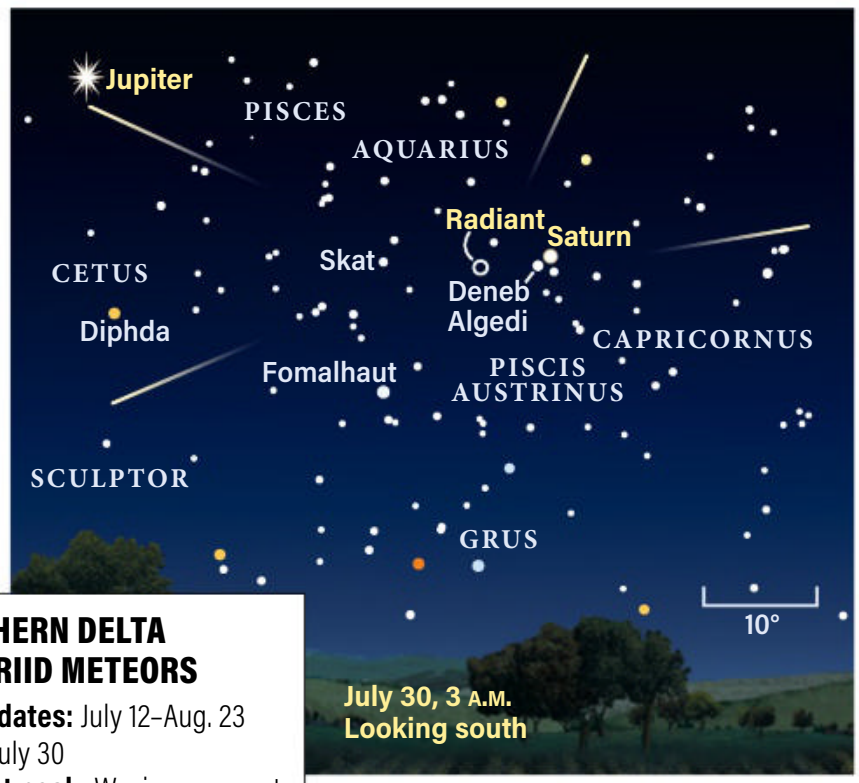
If they had central peaks, we would see those as bumps in profile, but this quartet appears to have flat floors. Their front and back rims stand out brightly in the stark sunlight because they face us almost directly. The views from the 13th to the 15th are wonderfully 3D because every shadow stretches away from the feature that casts it. Can you pick out two craterlets inside Cremona?

All four craters are named for European mathematicians. The most prominent — and classical — crater well interior of the limb is Pythagoras, perhaps the inspiration for names in this part of the Moon.

This geometry is only possible when we catch the Full Moon close to the bottom of its up-and-down bobbing motion around Earth. The 27.2-day cycle quickly loses synch with the 29.5-day parade of phases each month. From our northern perspective, we are now looking down past the crown of Luna's head. In about nine years, the summer Full Moon will sit at its maximum above the ecliptic, giving us a view under its chin.

METEOR WATCH | When the Moon is New

Southern Delta Aquariid meteors



The Southern Delta Aquariids' radiant doesn't climb very high for northern observers, but a moonless sky improves your chances.

SOUTHERN DELTA AQUARIID METEORS
Active dates: July 12–Aug. 23
Peak: July 30
Moon at peak: Waxing crescent
Maximum rate at peak: 25 meteors/hour

A NEW MOON on July 28 coincides closely with the peak of the Southern Delta Aquariid meteor shower, active from July 12 through Aug. 23 and peaking the morning of July 30. Meteors from this shower tend to be faint and reach less than a dozen per hour from most North American sites, although the zenithal hourly rate (when the radiant is overhead, for locations in the Southern Hemisphere) is predicted at 25 per hour. For northern observers, the radiant — near the star Skat in Aquarius — reaches only 30° elevation at 3 A.M. local time.

Other meteor showers are also occurring, though at low rates, but their combined frequency makes moonless mornings late this month favorable. The Perseids begin their slow buildup at the end of July and, with a Full Moon next month during their peak, late July and early August are good times to spot the first members of this shower.

STAR DOME

HOW TO USE THIS MAP

This map portrays the sky as seen near 35° north latitude. Located inside the border are the cardinal directions and their intermediate points. To find stars, hold the map overhead and orient it so one of the labels matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at:

midnight July 1
11 P.M. July 15
10 P.M. July 31

Planets are shown at midmonth

MAP SYMBOLS

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

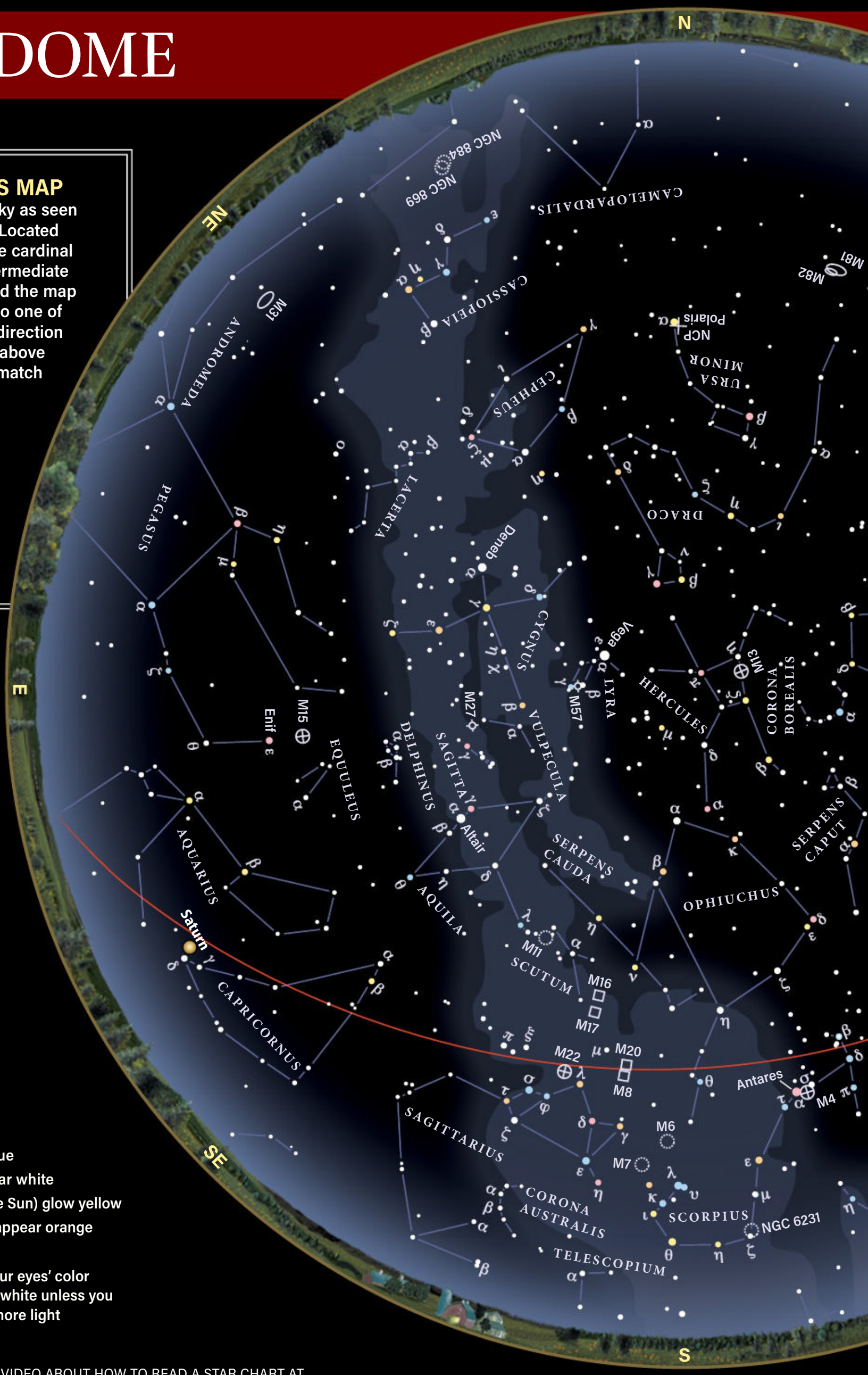
STAR MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

STAR COLORS

A star's color depends on its surface temperature.

- The hottest stars shine blue
- Slightly cooler stars appear white
- Intermediate stars (like the Sun) glow yellow
- Lower-temperature stars appear orange
- The coolest stars glow red
- Fainter stars can't excite our eyes' color receptors, so they appear white unless you use optical aid to gather more light



BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**

JULY 2022

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.

CALENDAR OF EVENTS

1 Venus passes 4° north of Aldebaran, 8 P.M. EDT

4 Earth is at aphelion (94.5 million miles from the Sun), 3 A.M. EDT

6 First Quarter Moon occurs at 10:14 P.M. EDT

12 Asteroid Vesta is stationary, 2 A.M. EDT

13 The Moon is at perigee (221,993 miles from Earth), 5:06 A.M. EDT

Full Moon occurs at 2:38 P.M. EDT

15 The Moon passes 4° south of Saturn, 4 P.M. EDT

16 Mercury is in superior conjunction, 4 P.M. EDT

17 The Moon passes 3° south of Neptune, 9 P.M. EDT

18 The Moon passes 2° south of Jupiter, 9 P.M. EDT

19 Pluto is at opposition, 10 P.M. EDT

20 Last Quarter Moon occurs at 10:19 A.M. EDT

21 The Moon passes 1.1° north of Mars, 1 P.M. EDT

Dwarf planet Ceres is in conjunction with the Sun, 9 P.M. EDT

22 The Moon passes 0.2° north of Uranus, 2 A.M. EDT

26 The Moon is at apogee (252,447 miles from Earth), 6:22 A.M. EDT

The Moon passes 4° north of Venus, 10 A.M. EDT

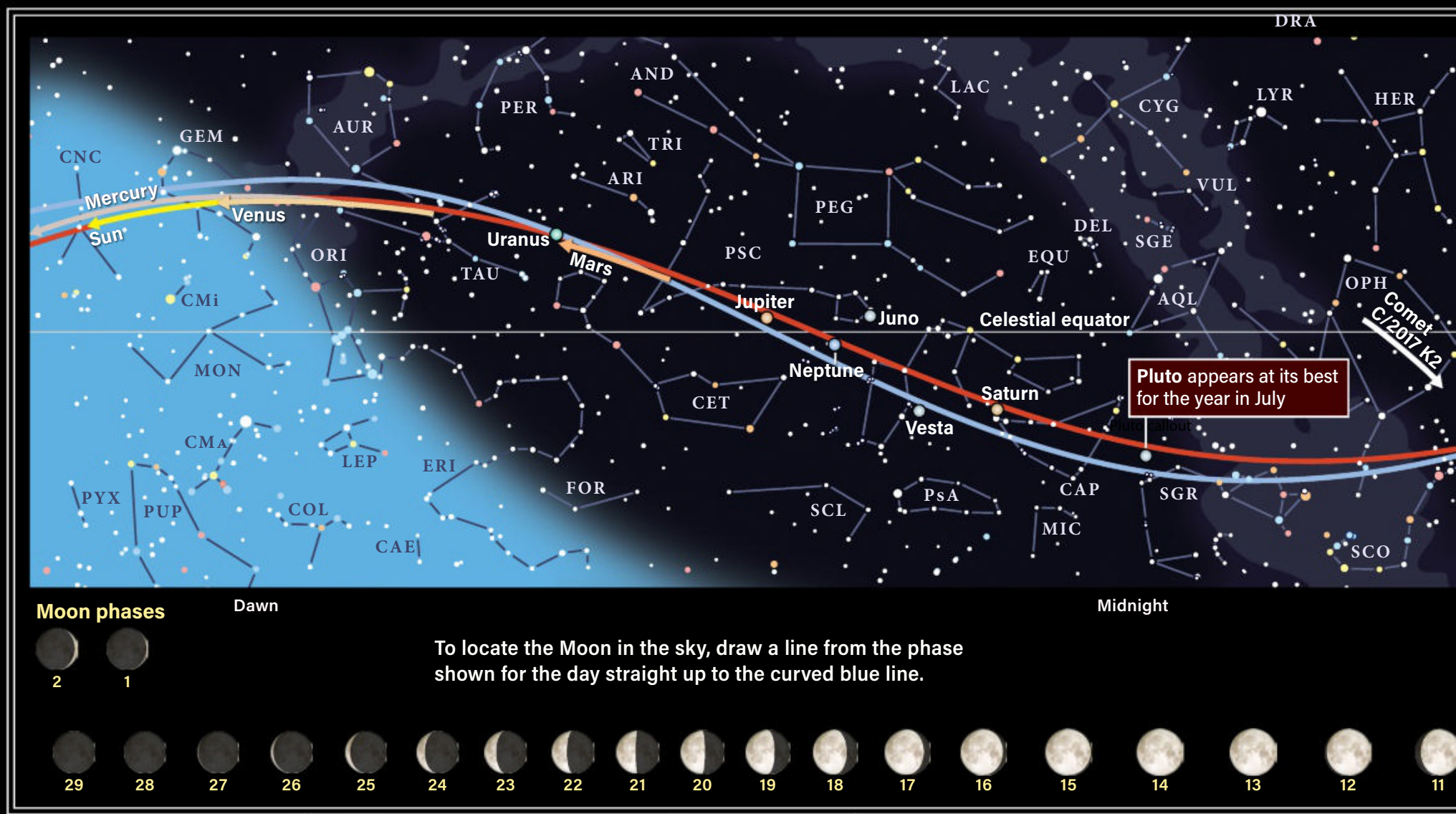
28 Asteroid Juno is stationary, 6 A.M. EDT

New Moon occurs at 1:55 P.M. EDT

29 Jupiter is stationary, 8 A.M. EDT

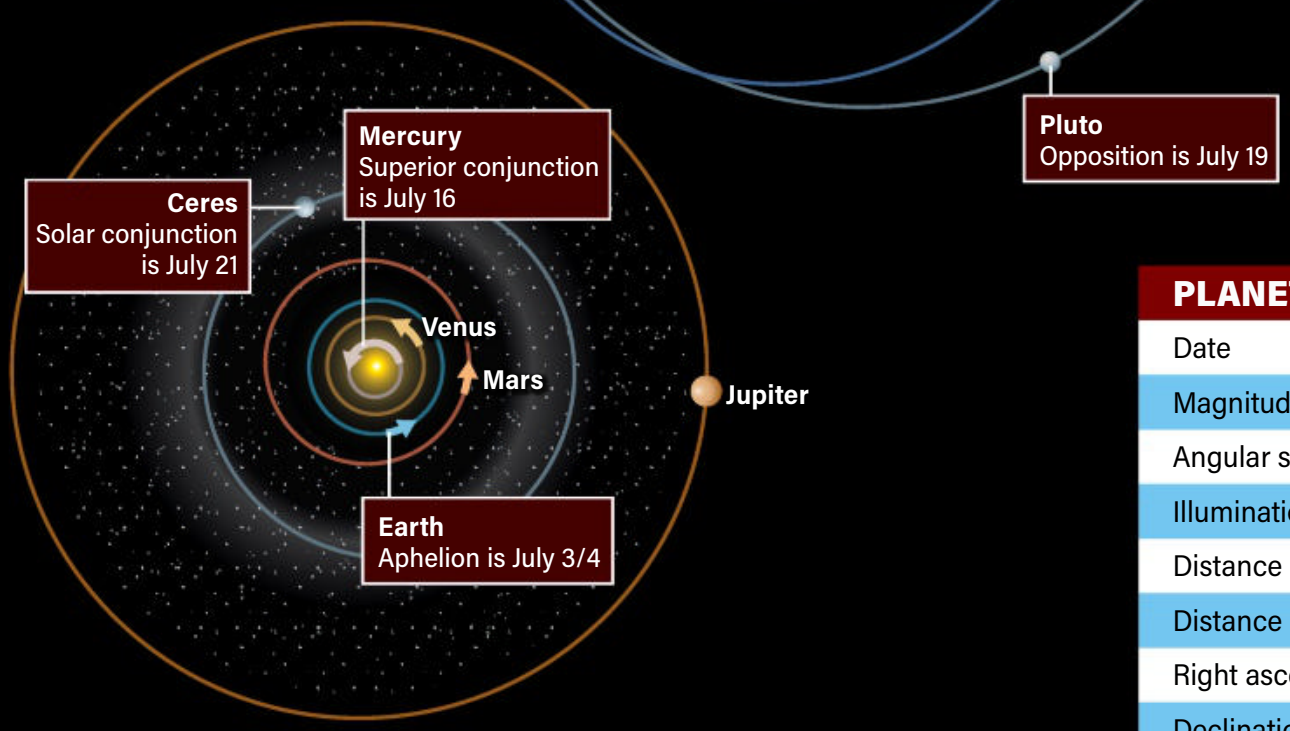
30 Southern Delta Aquariid meteor shower peaks

PATHS OF THE PLANETS



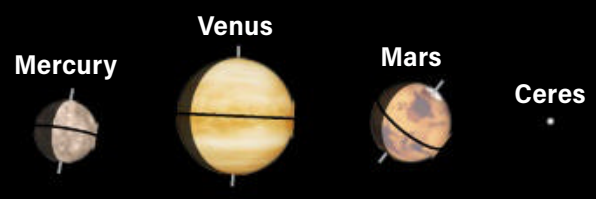
THE PLANETS IN THEIR ORBITS

Arrows show the inner planets' monthly motions and dots depict the outer planets' positions at midmonth from high above their orbits.



THE PLANETS IN THE SKY

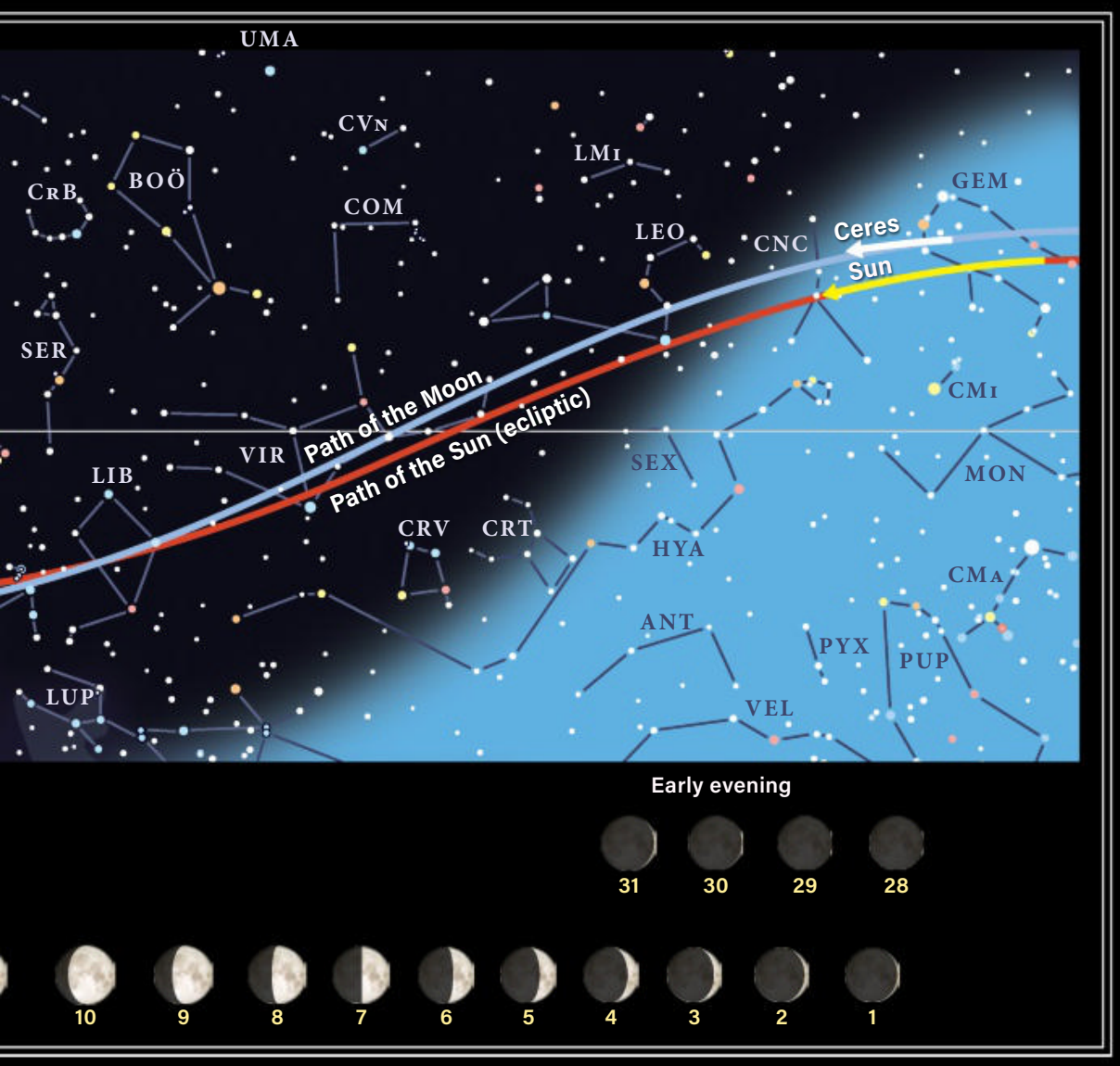
These illustrations show the size, phase, and orientation of each planet and the two brightest dwarf planets at 0h UT for the dates in the data table at bottom. South is at the top to match the view through a telescope.



PLANETS	MERCURY	VENUS
Date	July 1	July 15
Magnitude	–0.7	–3.9
Angular size	6.0"	11.3"
Illumination	72%	89%
Distance (AU) from Earth	1.123	1.478
Distance (AU) from Sun	0.335	0.723
Right ascension (2000.0)	5h24.4m	5h42.7m
Declination (2000.0)	22°08'	22°34'

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

JULY 2022



Callisto

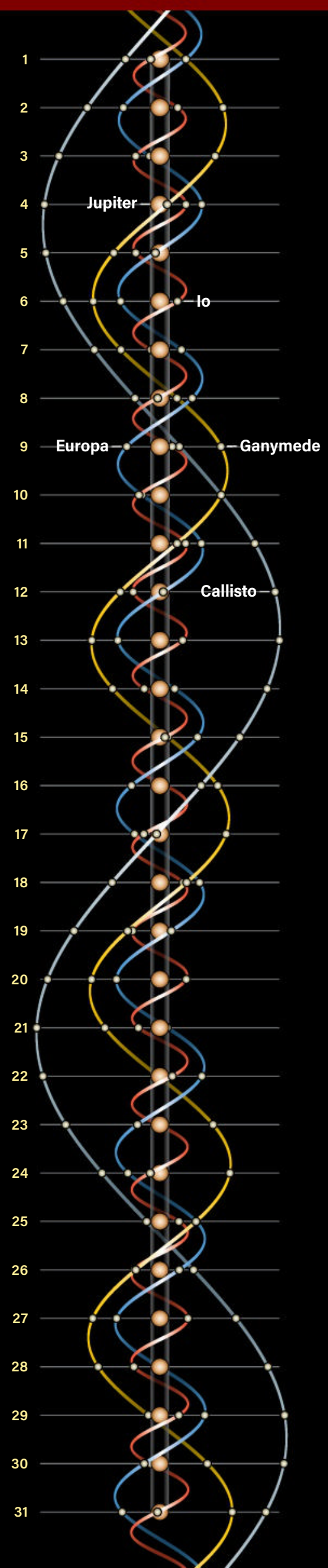
Europa

Io

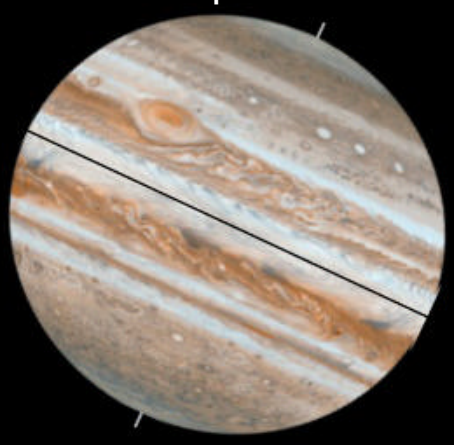
Ganymede

JUPITER'S MOONS

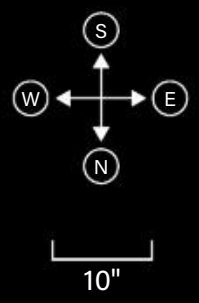
Dots display positions of Galilean satellites at 4 A.M. EDT on the date shown. South is at the top to match the view through a telescope.



Jupiter



Saturn



Uranus

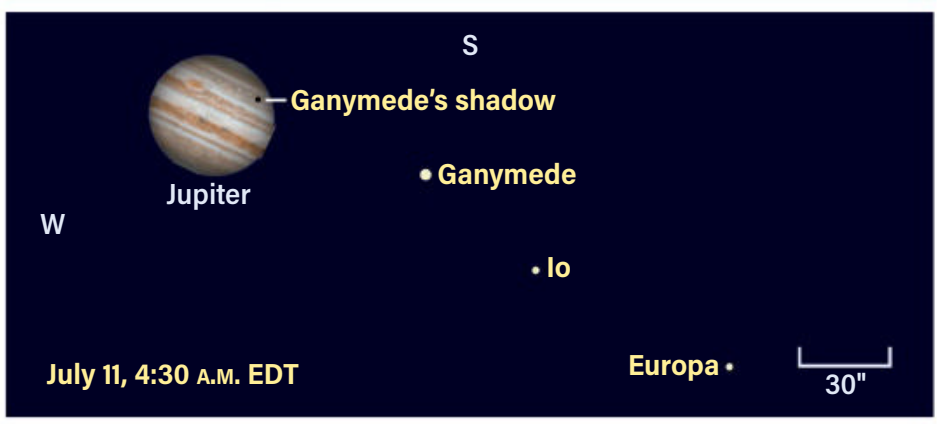
Neptune

Pluto

MARS	CERES	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
July 15	July 15	July 15	July 15	July 15	July 15	July 15
0.3	8.5	−2.5	0.4	5.8	7.7	15.0
7.7"	0.4"	42.7"	18.5"	3.5"	2.3"	0.1"
85%	100%	99%	100%	100%	100%	100%
1.223	3.594	4.615	8.996	20.115	29.439	33.552
1.385	2.585	4.961	9.877	19.695	29.916	34.564
2h18.9m	7h55.0m	0h31.9m	21h45.8m	3h02.4m	23h43.7m	19h58.6m
11°59'	25°30'	1°58'	−14°47'	16°50'	−3°04'	−22°49'

 — *Continued from page 33*

Shadow crossing



The morning of July 11, Ganymede's shadow slowly crosses the face of Jupiter. (Callisto, not pictured here, lies farther east.) Europa will follow the next morning.

relative to Saturn. Despite this, we are now moving toward the 2025 ring plane crossing, when the rings will appear edge-on.

Small scopes will spy Titan, Saturn's largest moon — an easy target at magnitude 8.5. You'll find it north of Saturn July 4/5 and 20/21, and due south July 11/12 and 27/28.

Much closer to the planet are the fainter moons Tethys, Dione, and Rhea. They shine at 10th magnitude and orbit with periods ranging from two to five days. Their constantly changing aspect is fascinating to follow.

Neptune has crossed into Pisces after many years in Aquarius. It stands 5° due south of Lambda (λ) Piscium, the southeasternmost star in the Circlet of Pisces. Neptune shines at magnitude 7.7. It rises soon after midnight in early July and is well placed in the southeastern sky in the two hours before dawn. You can get its approximate location from Jupiter: Neptune is about 12° west of the gas giant. Neptune will require binoculars or telescope to find its dim bluish disk, which spans a mere 2".

Jupiter spends the entire month in Cetus and reaches its stationary point July 29. Starting at magnitude –2.4 and brightening by 0.2 magnitude by month's end, the giant planet is easy to spot. Rising nearly an hour after midnight on July 1 and a just over an hour before midnight by July 31, Jupiter is well placed throughout the morning hours. The best views come closer to dawn, when it is high in the southern sky.

Jupiter's disk grows in apparent size from 41" to 45", offering a wealth of detail even with small telescopes. Look for the dark equatorial belts straddling the equator. The planet's temperate zones offer subtle features and contain many spots, both dark and bright, which move noticeably within 10 minutes.

The four Galilean moons orbit Jupiter every two to 16 days, offering a constantly changing display as they and their shadows transit Jupiter's disk. There are two nice events this month involving Jupiter's largest moon, Ganymede. On the morning of July 4, Ganymede transits across the disk, starting at 4:41 A.M. CDT (already bright twilight in the Eastern time zone; East Coast observers can catch the moon's shadow transiting that morning before 3 A.M. EDT). The next day, July 5, Europa transits beginning at 1:17 A.M. EDT.

A similar event takes place one orbit later, on July 11, when Ganymede's shadow transits starting at 3:55 A.M. EDT. The slow-moving shadow takes just over three hours to cross the planet's face. The next day (July 12), Europa transits the disk starting at 3:50 A.M. EDT, taking

WHEN TO VIEW THE PLANETS

EVENING SKY
Mercury (west)

MIDNIGHT
Jupiter (east)
Saturn (southeast)
Neptune (east)

MORNING SKY
Mercury (east)
Venus (east)
Mars (east)
Jupiter (southeast)
Saturn (south)
Uranus (east)
Neptune (south)

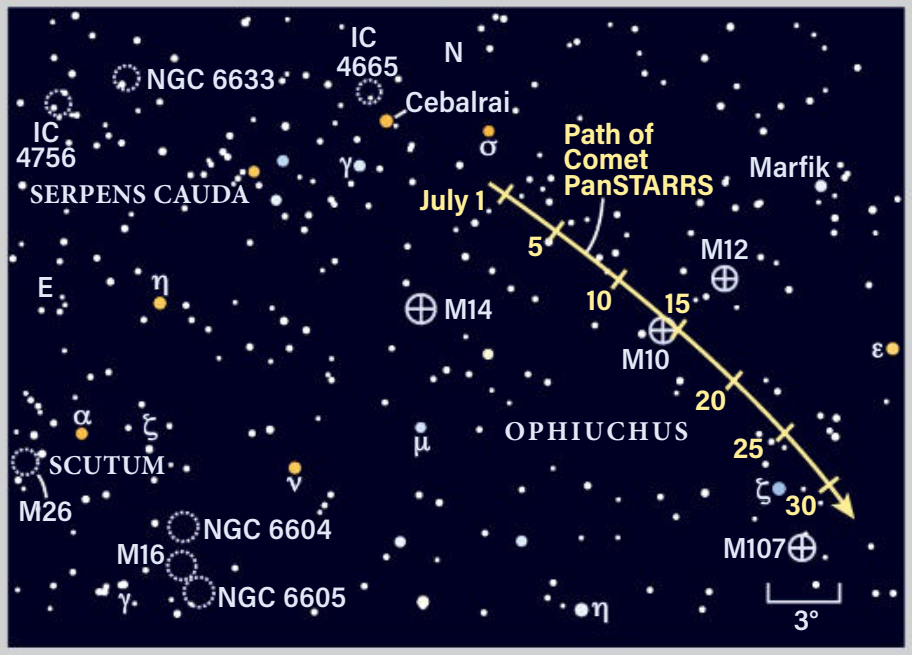
COMET SEARCH | Two-eyed nights

ALL SUMMER LONG, Comet C/2017 K2 (PanSTARRS) glows in binoculars just west of the magnificent Milky Way. It's a perfect time to get (re)acquainted with the bright deep-sky objects that just miss the prime dark observing region along our galaxy's spine.

Start at magnitude 2.8 Beta (β) Ophiuchi; PanSTARRS lies one binocular field southwest. Now swing back to Beta and take in the large star cluster IC 4665 at 10 o'clock. Closer to Aquila are NGC 6633 and IC 4756, set against a rich starry background.

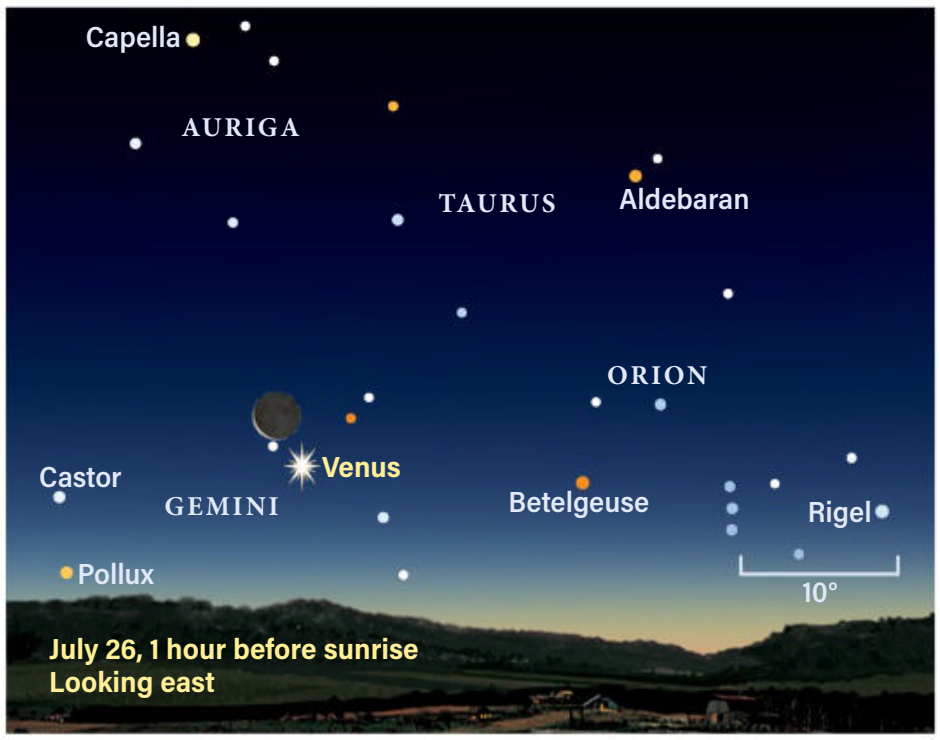
Compare the comet to globular clusters M10 and M12. PanSTARRS will be less than 1° from M10 from the 13th to the 15th, sadly with a nearly Full Moon in the sky. Still, don't let that stop you from trying to spot it from the suburbs with a 6-inch scope. PanSTARRS will be a smidge fainter than M12's magnitude of 6.1 and M10's 6.6, but comets can have outbursts so we might be in luck. Dark skies return the weekend of the 22nd, when you can compare with M107 (magnitude 7.9). Globulars are generally very round, but the comet's stubby fan should give it a soft northern flank and well-defined bow on the Sun-facing south.

Comet C/2017 K2 (PanSTARRS)



Comet PanSTARRS makes its way through a region rich with star clusters for comparison this month.

Traveling the Twins



Venus spends the month in a rich region of the sky, passing M1 and M35 before sharing the morning twilight with a crescent Moon July 26.

less than two hours to complete its journey.

Io and its shadow traverse Jupiter in a repeating sequence on the mornings of July 8th (from 2:19 A.M. EDT), 15th (from 4:11 A.M. EDT), and 22nd (from 5:02 A.M. CDT — note this is in daylight in the Eastern time zone). July 22nd includes Ganymede reappearing from behind Jupiter at 4:58 A.M. CDT, just before Io's transit begins. Io joints its own shadow for a transit July 31st at 2:20 A.M. EDT.

Callisto is far enough out that the slight tilt in its orbital plane relative to Earth causes it to miss Jupiter entirely. On July 17 around 1 A.M. EDT, Callisto lies south of Jupiter's south pole.

Mars rises among the faint stars of Pisces shortly before 2 A.M. local time on July 1. The planet grows slowly brighter this month, from magnitude 0.4 to 0.2. It starts July 20° east of Jupiter and drifts eastward from night to night. On July 2, the Red Planet lies 13' due south of 4th-magnitude Omicron (o) Piscium. Mars crosses into Aries July 9; a waning crescent Moon joins it in the Ram July 21, less than 3° away by sunrise. On July 31, Mars rises soon after midnight and stands 11° north of Menkar, a magnitude 2.5 star in Cetus the Whale.

Mars reveals its 8"-wide face through telescopes and shows a nice 85-percent-lit gibbous disk. You will need lucky moments of steady atmospheric seeing to spot details. High-speed video capture with long-focal-length telescopes and extensive processing will begin to bring out features. Mars reaches opposition in December, when the apparent size of its disk will be more than 2 times larger.

Venus stands 4° due north of Aldebaran, the brightest star in Taurus, before dawn on July 1. It rises about 3:45 A.M. local time and by 4:30 A.M. is well clear of the horizon, adjacent to the stars of the Hyades.

Each morning, Venus slides farther east, passing 24' north of the Crab Nebula (M1) July 13. Venus then spends three days — July 16 to 18 — crossing the extreme northern edge of Orion before moving into Gemini the Twins. The glowing planet sits 1.5° south of the open star cluster M35 on July 20. A very fine waning crescent Moon stands less than 4° north of Venus on July 26 — a glorious early-morning display just as Castor and Pollux, Gemini's twin 1st-magnitude stars, rise to greet the dawn.

Through a telescope, Venus changes from an 86-percent-lit disk spanning 12" on July 1 to 92 percent lit and 11" wide on July 31. Its magnitude remains a constant –3.9 all month.

Earth reaches aphelion, the farthest point from the Sun in its orbit, on July 4.

GET DAILY UPDATES ON YOUR NIGHT SKY AT
www.Astronomy.com/skythisweek.

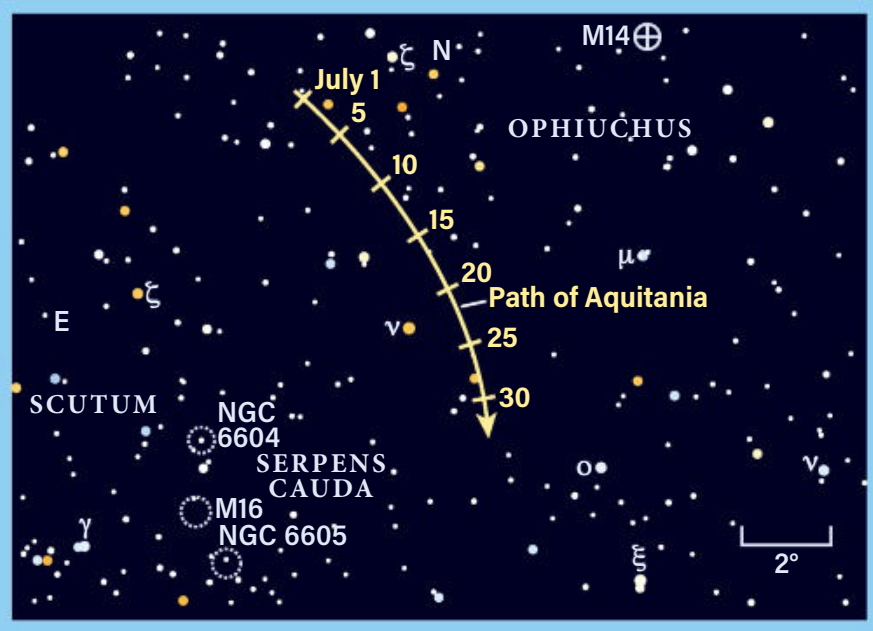
LOCATING ASTEROIDS |
Hitting the high numbers

THE TIME IS RIGHT: An asteroid reaches maximum brightness when it is simultaneously closest to the Sun and Earth. Main-belt objects tend to be discovered in order of their size (bigger is brighter), which is why we rarely feature asteroids with numbers above 100. 387 Aquitania has a fairly eccentric, egg-shaped orbit that brings this 60-mile-wide world closer in while Earth is farthest out, causing the asteroid to shine brighter than average.

To spot Aquitania, you'll need a 3-inch scope from the country or a 6-inch under suburban skies. Though close to the Milky Way, the magnitude 10 dot is cruising in front of the Great Rift, whose dust obscures innumerable background stars. Nu (ν) Ophiuchi serves as a nice magnitude 3.1 starting point. Sweep northeast until you reach Aquitania's predicted position. Come back a night or two later to see that it shifted. From the 25th to the 29th, Aquitania passes two notable field stars, making this easy.

This space rock was named after the region in France where the observatory that discovered it was located, as astronomers had run out of Greek gods and muses by 1894. Good alignments between Aquitania and Earth occur every nine years, but the best come in almost 100-year intervals. We're slipping out of phase, so the next issue of *Astronomy* to highlight Aquitania will be in 2122!

Now's your chance



Aquitania is brighter than usual this month and won't put in another appearance this good for a century.

Martin Ratcliffe *is a planetarium professional with Evans & Sutherland and enjoys observing from Wichita, Kansas.*
Alister Ling, *who lives in Edmonton, Alberta, is a longtime watcher of the skies.*

VISIONS OF OUR MILKY WAY

The billions of stars in our home galaxy present artists with infinite possibilities for transporting us to other worlds. BY RON MILLER

THE MILKY WAY AND ITS COUNTLESS STARS, nebulae, and exoplanets were latecomers to space art. The reason is pretty simple: No one knew very much about what lay beyond the limits of our own solar system until the past century or so.

There were depictions of the Milky Way, of course, and the stars and Moon appear in petroglyphs and on seals and decorative objects dating as far back as 1600 B.C. By the 19th century, entire atlases of the sky were being published. They were as scientifically accurate as possible for the time, but often beautifully embellished by imaginative illustrations of the mythologically-inspired constellations.

However, there is a fundamental difference between recording something for science — or even just plain curiosity — and creating a unique work of art because the subject inspires you. It is the difference, say, between an academic treatise on cetology and *Moby-Dick*. It's one thing to accurately place a star in its proper position on a chart of the night sky, and another to wonder what that star might look like if you were to visit it or stand on one of its planets.

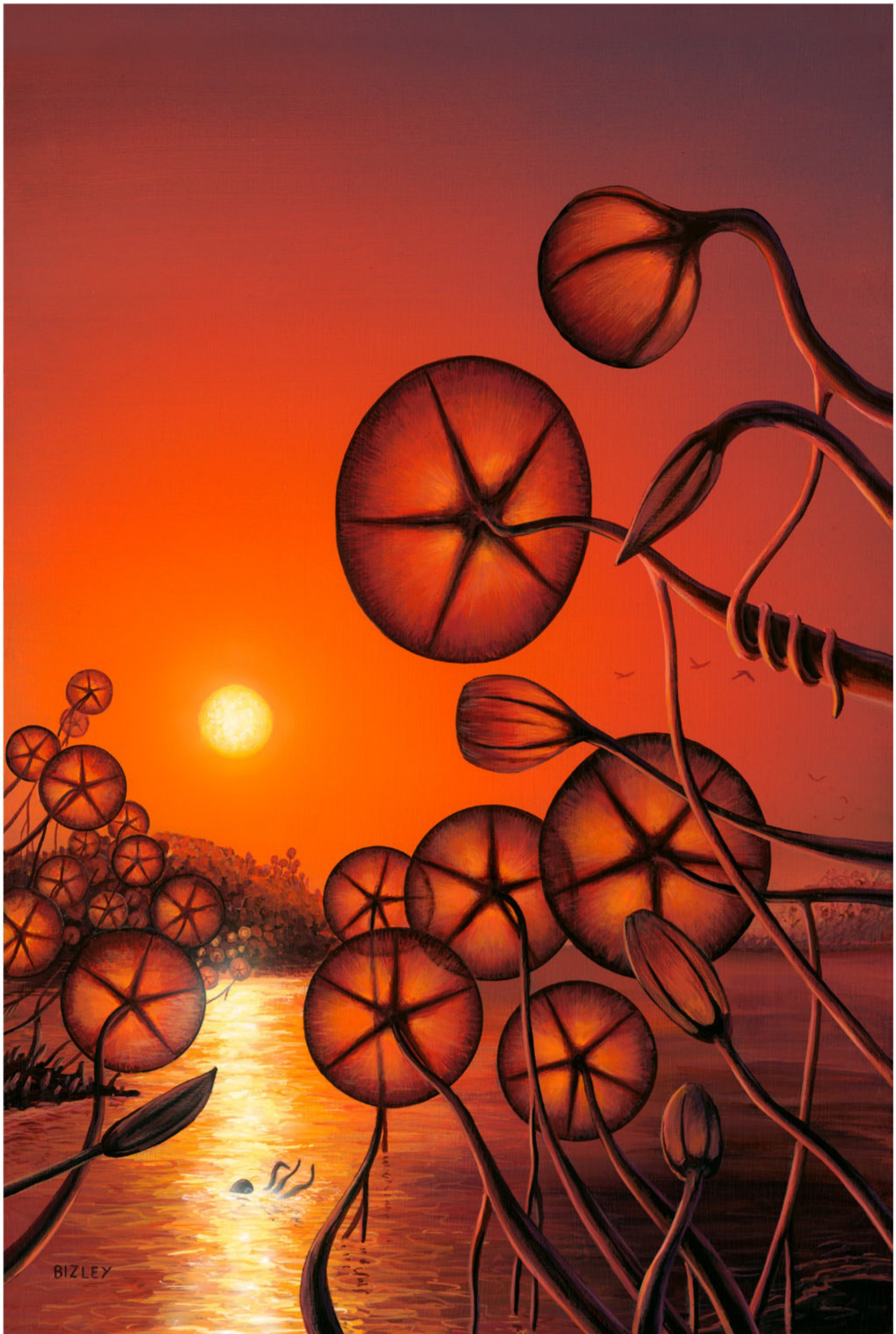
It wasn't until 1923 that "spiral nebulae" such as the Andromeda Galaxy were found to be island universes separate from our own galaxy. And until astronomers understood the true nature of stars and the Milky Way, little inspiration existed for artists to paint them.

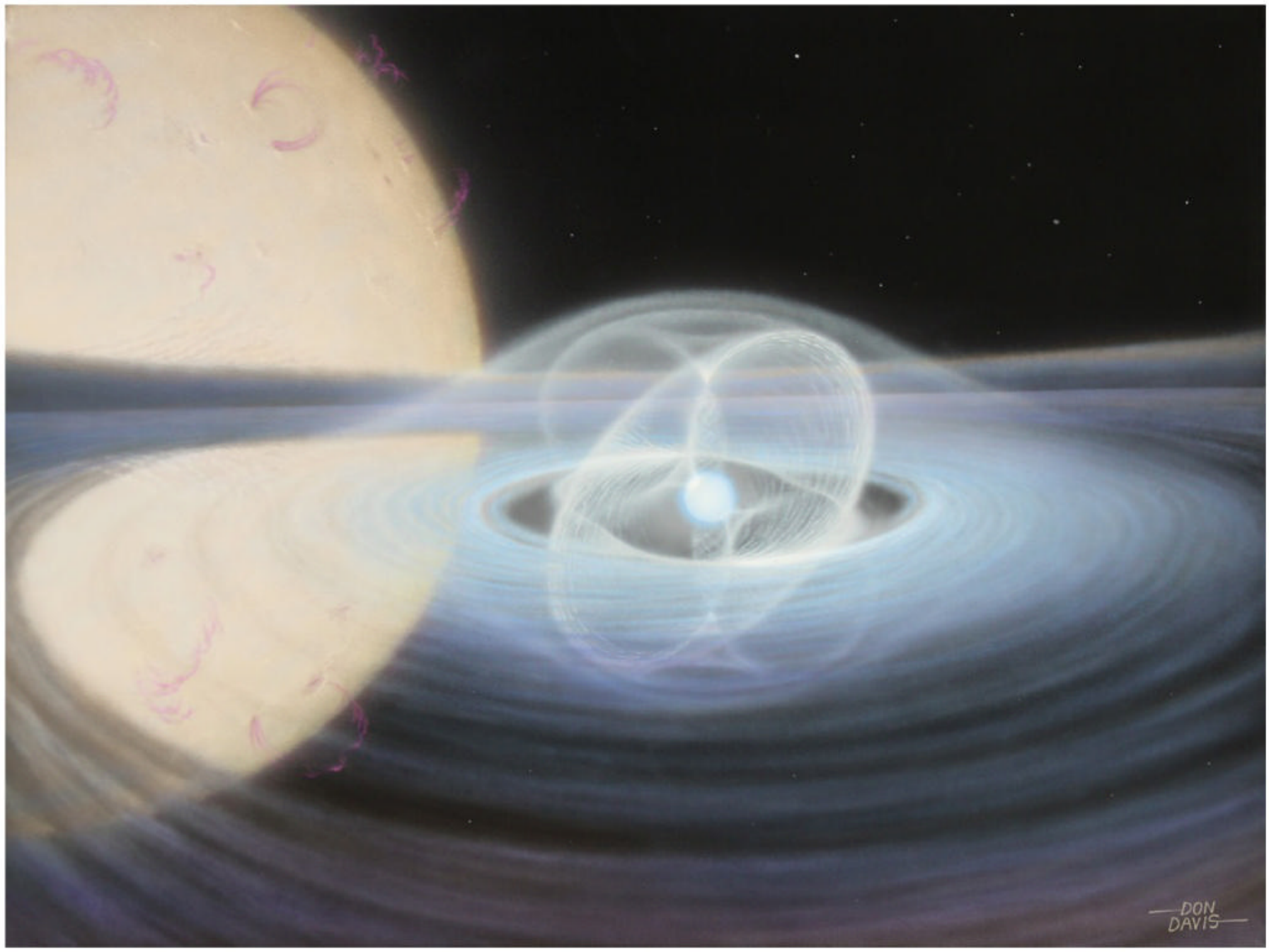
Probably the first artist to wonder what it might be like to stand under a different star than the Sun was the French artist-astronomer Lucien Rudaux (1874–1947). Like the great American space artist Chesley Bonestell (1888–1986), Rudaux had been a commercial illustrator who developed

RICHARD BIZLEY
Life on a Tidally-Locked World

Acrylic

In this scene on a tidally locked world, the parent star of the imagined planet never rises or sets. The world's plants are all seen facing the same direction, competing with each other to reach toward the light. Something is disturbing the waters ... possibly an intelligent animal.


BIZLEY



DON DAVIS

Hercules X1

Acrylic

The X-ray binary Hercules X-1 consists of a neutron star closely orbiting a larger star. Material from the larger star interacts with the neutron star's intense magnetic field as it falls in.

a serious interest in astronomy. So serious was he that a crater on Mars is named for him, not for his work as a space artist but for his contributions to science.

In the mid-1930s, Rudaux wrote and illustrated a series of astronomy articles for *American Weekly* magazine. These included "Other Suns With Worlds of Their Own Like Ours?" In this story, nine color paintings depicted scenes on planets orbiting a white dwarf, a red giant, and binary stars; planets within a star cluster; and others. The illustrations speculated not only on the appearance of the stars in the sky, but on how they would affect conditions on the accompanying planets.

Knowing that double stars existed with stars of different colors, Rudaux wondered what visual effects that might produce, and what it might be like to stand on a planet orbiting a binary star system. The result was a simple painting, but the first of its kind. The piece depicted a barren landscape dominated by large rocks casting colored shadows. Rudaux speculated on "the incomparable spectacle of a two-colored moon, created by the light it receives on either side from each of the two suns."

As astronomers probed ever deeper into our galaxy and learned more about how it came to be and how it functions, every new scrap of knowledge was an inspiration for space artists. Yes, we know what pulsars and black holes are, but how would one look? That is what inspires space artists, and sometimes it's not an easy question to answer.

I recall an instance when I needed to do an illustration of the Milky Way as it might appear from a planet orbiting a star far outside the galaxy. How bright would it be, I wondered? How might the Milky Way look to the

naked eye if we could see the entire galaxy? After all, we live inside it and the band of the Milky Way arching overhead is pretty dim. So, I decided to ask the great astronomer Bart Bok, a leading authority on the Milky Way, who ought to know everything there was to know about our galaxy. "Well," he said, "you know, I never really thought about that."

Therein lies, I think, one of the most important contributions space art can make to the science of astronomy. Many astronomers face two limitations in visualizing whatever it is they may be studying. One is that all too often, all that is known about an object is contained in pages of figures and graphs. It can be hard to translate that into something real.

Another is specialization. Focusing on just one narrow area of study can get in the way of visualizing something as a whole. A planetary scientist who is an expert on the climate of Mars may have only a general knowledge of the planet's geology. The space artist by necessity must draw from every possible source when creating an image, just as a paleontological artist needs to know everything about a dinosaur, from the shape of its teeth to the climate it lived in.

Possibly the most fruitful, and certainly the most exciting, new discoveries for space artists have been exoplanets. Exoplanets have long been a staple of science fiction, from *Forbidden Planet*'s Altair IV to *Star Wars*' Tatooine. Bonestell had assumed that such planets might exist. He created dozens of paintings of stars seen from the landscape of "a hypothetical planet." But these were the result of aesthetic decisions and not because Bonestell was inspired by any real places.

When the existence of exoplanets was confirmed with the discovery of the first in 1992, whole new vistas opened for space artists. Eventually, a regular menagerie of unusual and outright weird worlds appeared: super-Jupiters and brown dwarfs, planets with ring systems that dwarf Saturn's, worlds where it rains molten iron, eyeball planets with one frozen and one hot side, ocean and ice worlds, and even planets much like our own — or better.

With every new discovery comes new inspiration for the enthusiastic, curious crowd of space artists.

Ron Miller *is a longtime* Astronomy *contributor who designed the best-known early illustration of Pluto for the U.S. Postal Service in 1991.*

KEN NAIFF

Rho Ophiuchi

Photographic art

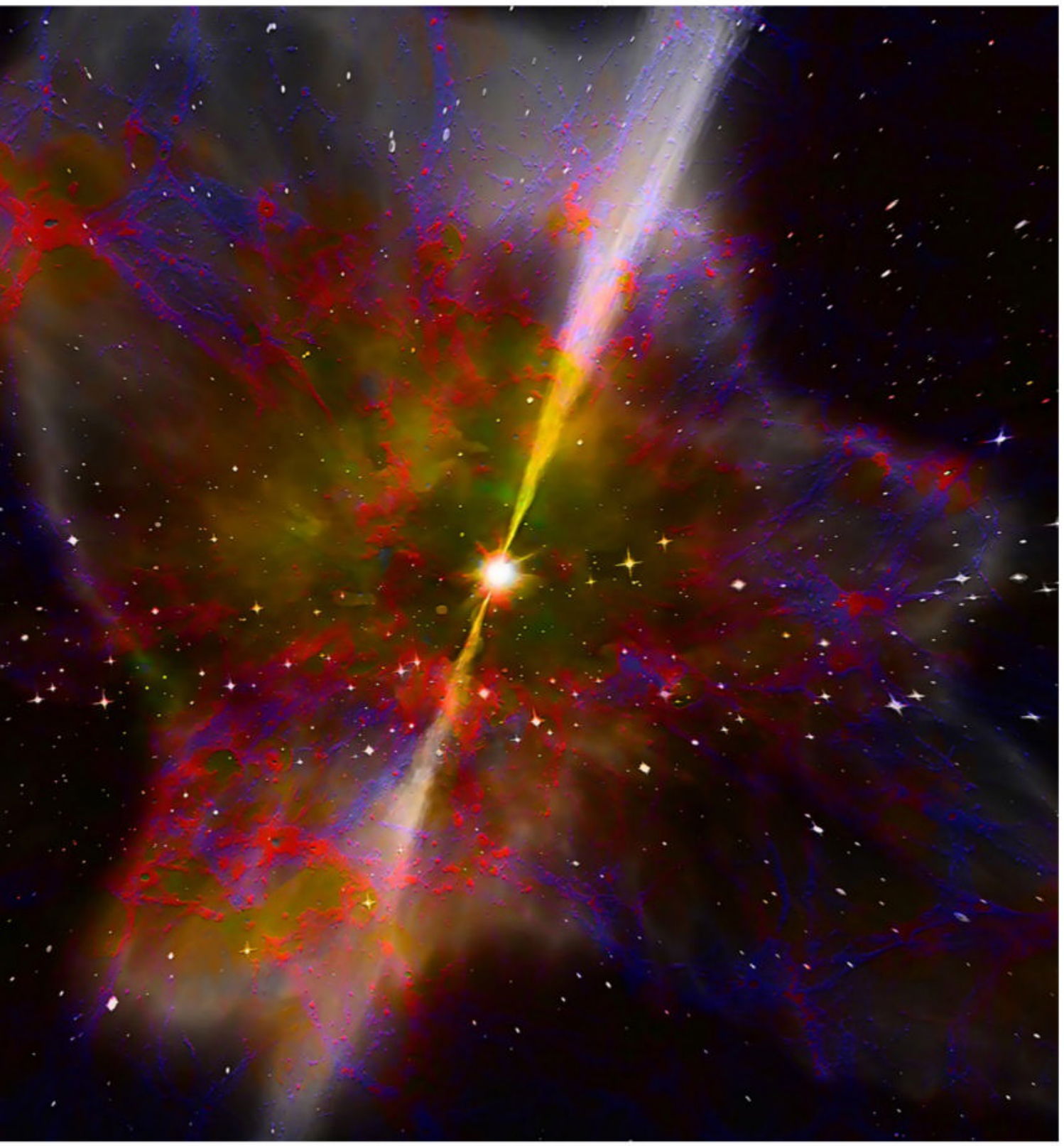
One of the closest star-forming regions to the Milky Way, the Rho Ophiuchi complex is a gigantic, colorful cloud of cosmic gas and dust located some 460 light-years from Earth.

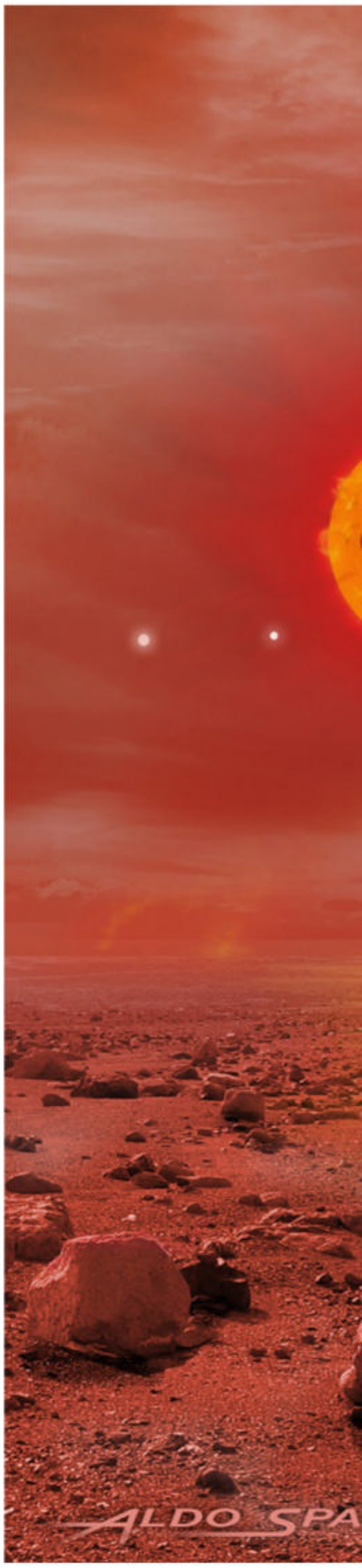
DON WHITE

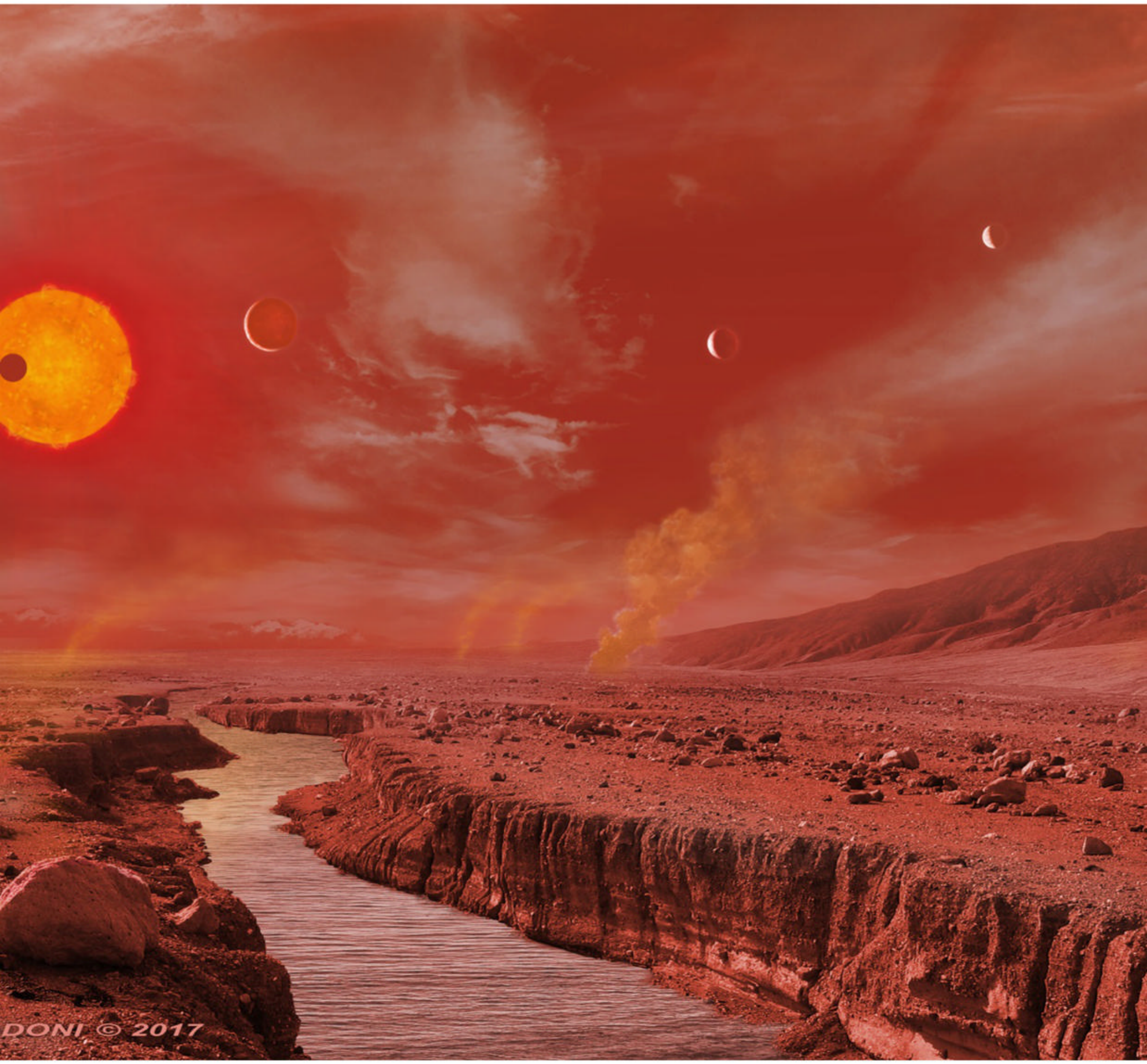
In the First Second

Watercolor/acrylic/digital

As a star takes its final breath before collapsing into a remnant, it compresses before exploding some of its matter into the surrounding cosmos.







ALDO SPADONI

TRAPPIST-1 Planetary System Viewed From the Surface

Digital

A hypothetical view of the TRAPPIST-1 system, as seen from the surface of one of its numerous planets.

"I've seen TRAPPIST-1 included in some artistic works. … It's like this system has a life of its own."

— **Michaël Gillon,** author of 2017 study revealing Trappist-1's seven sibling planets

PATTY HEIBEL

Fireball

Sculpture

Fireball sculptures represent glowing hot meteorites as they explode upon entering Earth's atmosphere. This example is made of mixed media including iron, bronze, and copper, and is presented on a manzanita branch.

DANA BERRY

Super Massive Black Hole Jetting

Digital

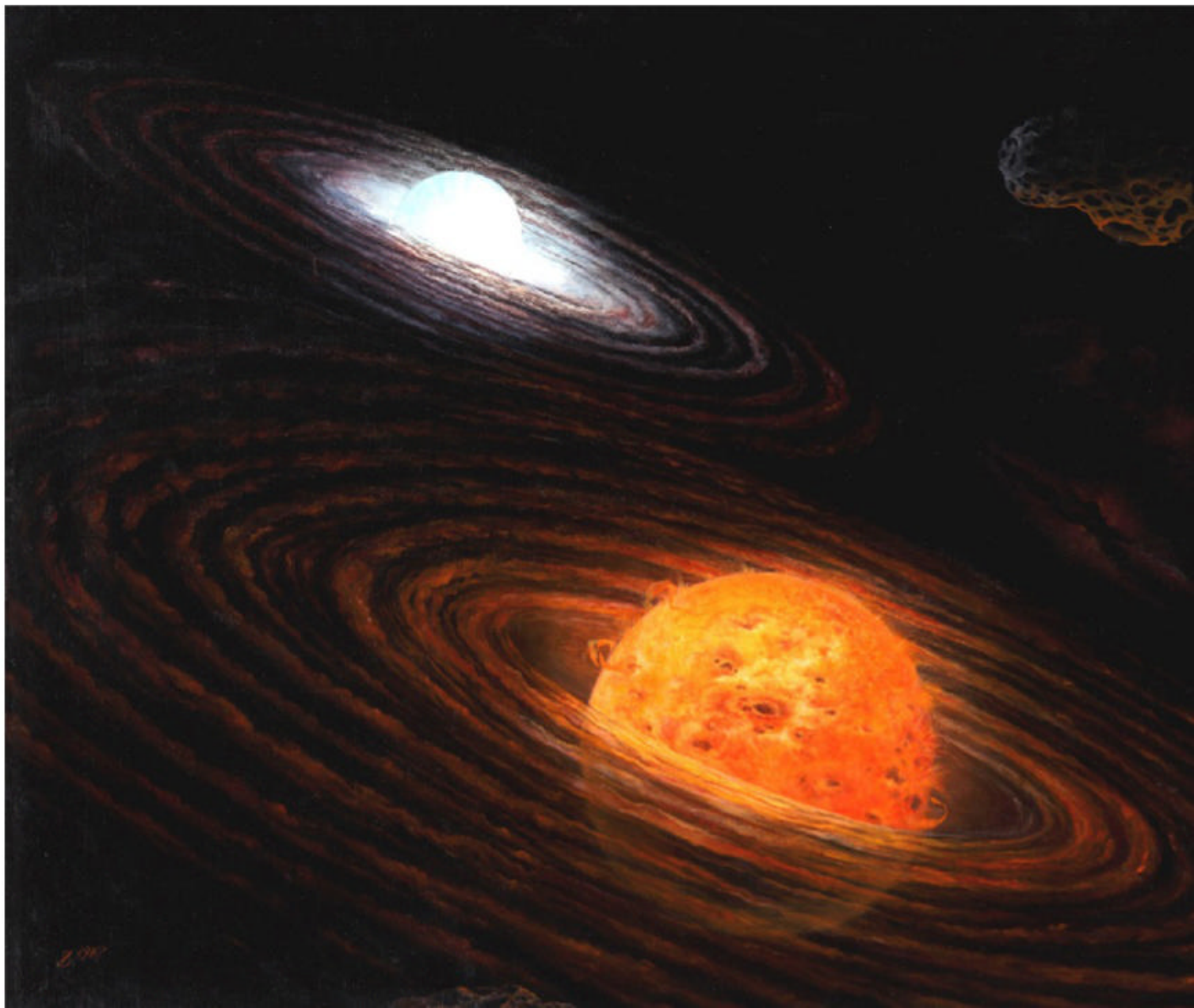
Originally commissioned by *Astronomy*, this work depicts the Milky Way's central supermassive black hole, which spouts energy outward as it guzzles matter.

ZINA SVIDERSKIENE

Red and Blue

Oil

Two young binary stars, born from the same cosmic cloud of material but of different mass, temperature, and luminosity, won't be tangoing for too long. The blue-white star will ultimately collapse into a black hole. Then it will start tearing away the red-orange star's outer layers, consuming the cooler partner's material. Asteroids in eccentric orbits — and maybe space tourists passing by while visiting the system — will bear witness to the impending drama.

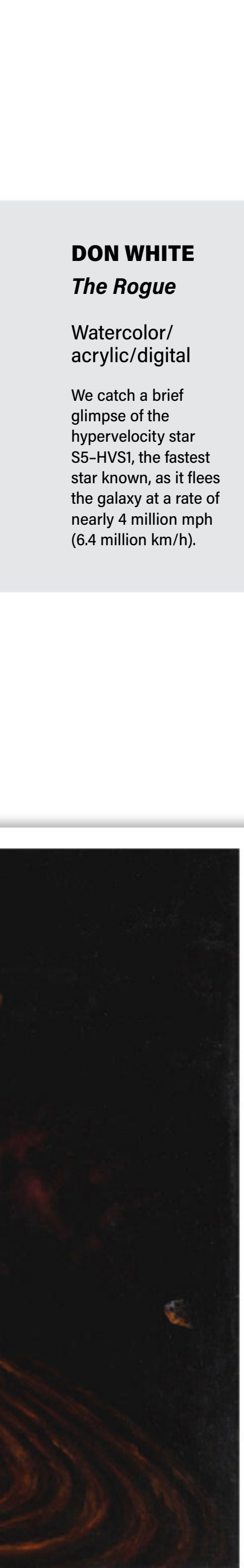


DON WHITE

The Rogue

Watercolor/
acrylic/digital

We catch a brief glimpse of the hypervelocity star S5–HVS1, the fastest star known, as it flees the galaxy at a rate of nearly 4 million mph (6.4 million km/h).



ROBIN HART

The Pillars of Creation

Fabric

A Hubble deep space photo was the inspiration for this patchwork piece of the Pillars of Creation in the Eagle Nebula. To re-create the stellar nursery, fabrics were applied in a grid pattern (to represent digital data). Applique and intricate threadwork help create the illusion of glowing gases, stars, and dust clouds.

"We now know that this kind of auroral behavior is extending all the way from planets up to brown dwarfs." — **Gregg Hallinan,** author of 2015 study uncovering aurorae on a brown dwarf

THOMAS O. MILLER

Brown Dwarf With Aurora

Digital

A brown dwarf looms over a planet during an intense auroral storm in this eerie scene. The magnetic field that flows between them creates an ethereal effect.

NURUL SYAHIRAH BINTI NAZARUDIN

The Pillars of Creation

Watercolor

The Pillars of Creation became iconic after Hubble's image of the towering dust clouds was reproduced all around the globe. This artistic take on the Pillars shows us a dramatic look at star formation.

EXTRAGALACTIC

In the universe's outer reaches, where telescopes fail us, artists can take over. BY JON RAMER

COMPARED TO THE UNIVERSE, human perspective is tiny. The fastest thing we know of is light, which travels at 186,282 miles (299,792 kilometers) per second. It takes light 8.3 minutes to travel from the Sun to Earth. Light needs over four years to cross the distance to the closest star outside our solar system, and 26,000 years to reach the center of the Milky Way. The nearest galaxy like our own is a dizzying 2.5 million light-years distant — but the rest of the universe? The rest of the universe is mind-bogglingly far away.

The latest estimates suggest there are over 200 billion galaxies in the universe, and over 90 percent of them are more than a billion light-years away. In fact, the light we see today from more than two-thirds of those galaxies was emitted before Earth even formed. We occupy a tiny, miniscule portion of a vast, vast cosmos.

It is difficult for the human mind to contemplate such tremendous scales, and just as difficult to study the myriad of fascinating objects that lie at them. But human curiosity and ingenuity is rising to that challenge. Our arsenal of astronomical tools has grown and improved at an ever-increasing rate over the past couple of hundred years. And so has another key factor in understanding the universe: the artists who depict those tremendous scales and fascinating objects.

Humans are visual creatures. For us, being able to see something is crucial to understanding it. Unfortunately, the farther away an object lies, the harder it is for our astronomical tools to see. But the imagination of an artist can leap across those light-years to paint a picture from a closer or different perspective, and bring new understanding. Artists have done this since the beginning of astronomy, and nowhere has this been more useful than in studying objects in the ever-increasing depths of space outside our own galaxy.

SAM DIETZE
Interstellar Filaments

Oil

This expressionistic image depicts one possible configuration of gas flowing through the early universe.

In the 1960s, Fritz Zwicky compiled a catalog of galaxies and galaxy clusters with nearly 40,000 objects in it. This catalog wasn't heralded just by scientists; it inspired artists by giving them a veritable smorgasbord of galactic shapes to paint. Spirals,

WONDERS

barred spirals, ellipticals, lenticulars, irregulars, ringed galaxies, interacting galaxies — the artistic possibilities were breathtaking, and so were the images artists created in response.

We now have photographs of millions of galaxies from optical telescopes both on and off Earth. All of them have the same, limited viewpoint: looking in from afar. But an artist can show us what a sky filled with a cluster of galaxies would look like from deep space, or the view of a galaxy from the surface of a nearby planet. Artists can drop us into the center of a distant gaseous whirlpool, or spread a spiral arm of stars across the sky to marvel at — sights our earthbound cameras will never be able to capture.

There is more to the universe than just visible light, though. Radio telescopes like the Very Large Array in New Mexico and the Atacama Large Millimeter/submillimeter Array in Chile have opened new realms of discovery, as have instruments that can collect X-rays, gamma rays, neutrinos, and even gravitational waves. Each new type of telescope has opened new ways to study the universe — like sampling particles from the cores of exploding stars and sensing the ripples in space-time caused by colliding black holes. With all of these come new artistic opportunities.

As fascinating as these rich troves of new data are, we cannot see what a radio telescope or gravitational-wave observatory sees. The data are just numbers. Although we can sometimes create false-color images from the streams of ones and zeros, their resolution is limited. But a skilled astronomical artist can take the reams of non-visible observations from an active galaxy 100 million light-years away and create a plausible up-close image depicting an erupting galactic core with vast jets of material shooting into the void, vividly illustrating the physics of these immensely powerful objects. Depictions of rarer and more mysterious deep-space objects rely even more heavily on artistic skill — like the event horizons of supermassive black holes, protogalaxies, and fast radio bursts.

Artists can also make sense of the most tenuously

MICHAEL C. TURNER
Cosmic Prophecy

Acrylic

A galaxy viewed from a dramatic angle reveals the nature of its spiral arms, which sweep into intergalactic space, displaying an array of treasures.

WILLIAM K. HARTMANN

Alien Planet With Colliding Galaxies in Sky

Acrylic

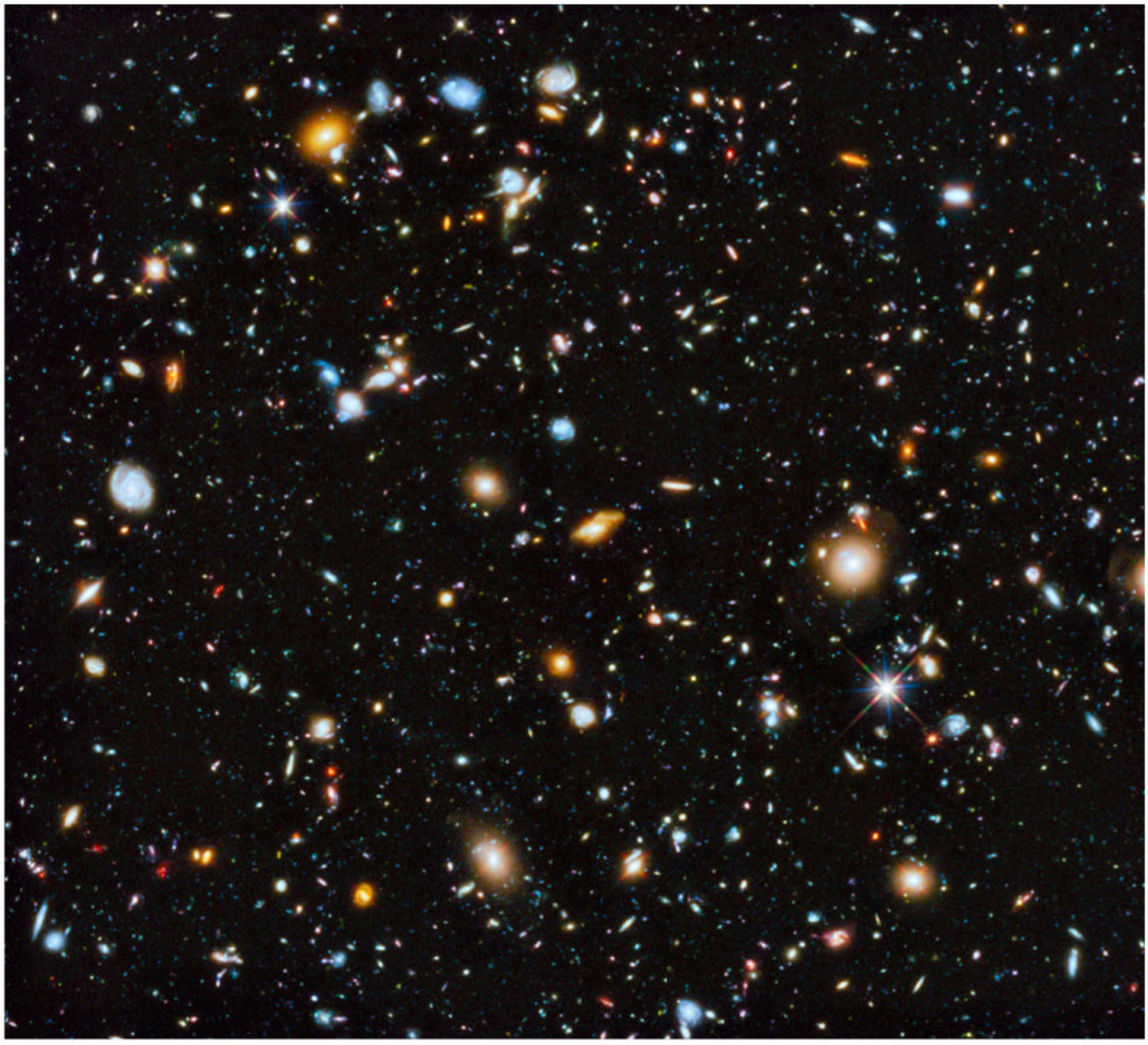
A watery planet orbits a star that has been ejected from its galaxy during a collision with another galaxy.

connected structures in the cosmos. For most of the 20th century, astronomers assumed that galaxy clusters were the universe's largest organized collections of matter. But in the 1980s, astronomers realized that structure exists on a much larger scale. Surveys detected vast walls and humongous filaments of galaxies crisscrossing the universe, and great empty voids that span hundreds of millions of light-years.

More recently, astronomers have analyzed hundreds of thousands of galaxies cataloged in the Sloan Digital Sky Survey and found that filaments may also have coherent motion. In 2021, a team of astronomers reported that these structures appear to rotate, their galaxies twisting around each other in astonishingly gigantic displays of angular momentum. The scale of such structures is almost unimaginable, but a well-crafted image can convey their immensity and complexity in an instant.

All of these discoveries help us understand how our universe began and evolved — and crucial to that understanding are the images created by astronomical artists.

Jon Ramer *is a career military officer and avid world traveler. He works in acrylics, oils, and digitally. A fellow of the IAAA, he has had works featured in several astronomical and scientific art shows. Most recently, he co-edited and wrote* The Beauty of Space Art *(Springer Nature, 2020).*



NASA, ESA, H. TEPLITZ AND M. RAFELSKI (IPAC/CALTECH), A. KOEKEMOER (STSCI), R. WINDHORST (ARIZONA STATE UNIVERSITY), AND Z. LEVAY (STSCI)

Hubble Ultra Deep Field

Digital photograph

The Hubble Ultra Deep Field (2014) was produced by combining over 2,000 exposures of the same small spot of sky taken over 10 years into one image. This image is made up of roughly 25 days of exposure time and shows about 10,000 galaxies.

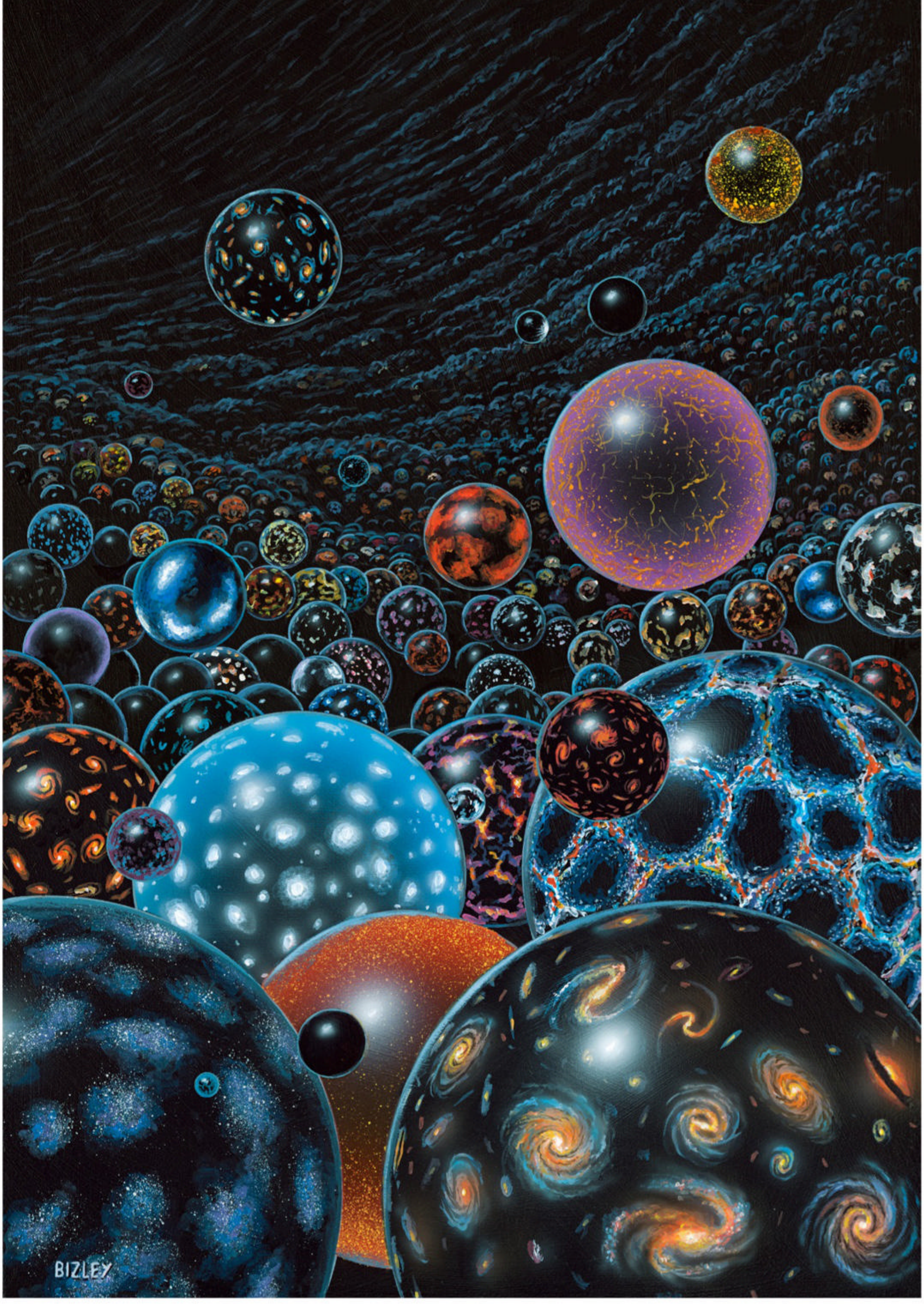
We occupy a tiny, miniscule portion of a vast, vast cosmos.

RICHARD BIZLEY

Eternal Ocean of Multiverses

Acrylic

This higher-dimensional view of the multiverse depicts a cluster of universes that happen to be "next door" to each other, each with different fundamental laws of physics.

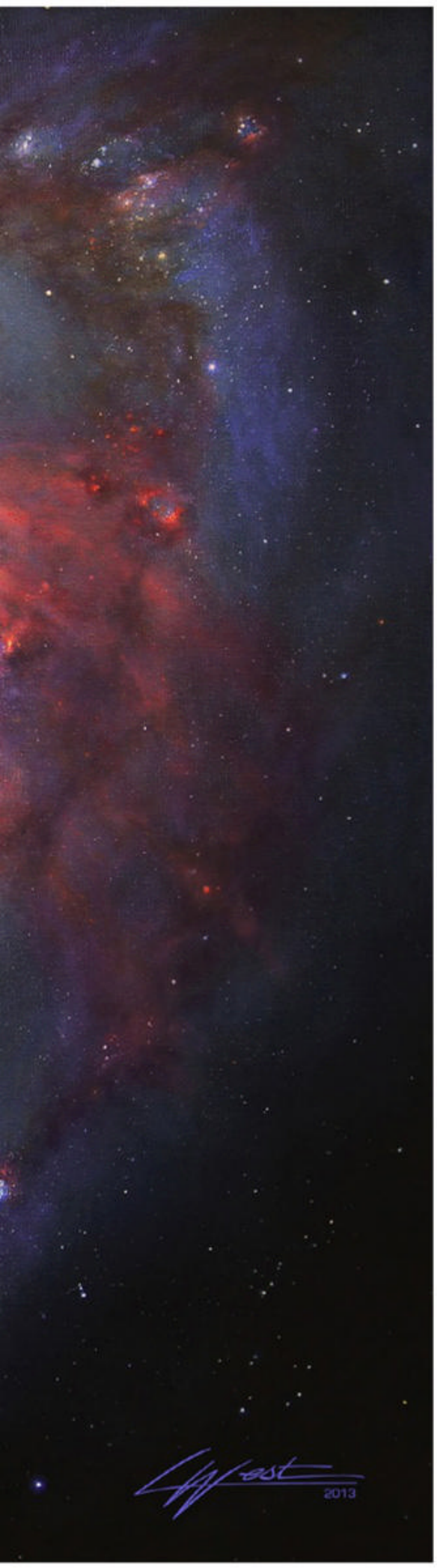

BIZLEY

LUCY WEST

Mighty M106

Acrylic

The spiral arms of galaxy M106 in Canes Venatici are laced with glowing patches of star formation and sprawling dust lanes, as captured in this detailed painting.



DANA BERRY

Hyper-Luminous Starburst Galaxies Merging 13 Billion Years Ago

Digital

Two protogalaxies at the dawn of the universe are colliding and undergoing starburst — a phase of intense star formation. This is a digital photocollage created in Maya and Photoshop.

Humans are visual creatures. For us, being able to see something is crucial to understanding it.

WALTER B. MYERS

Red Galaxy Sunset

Digital

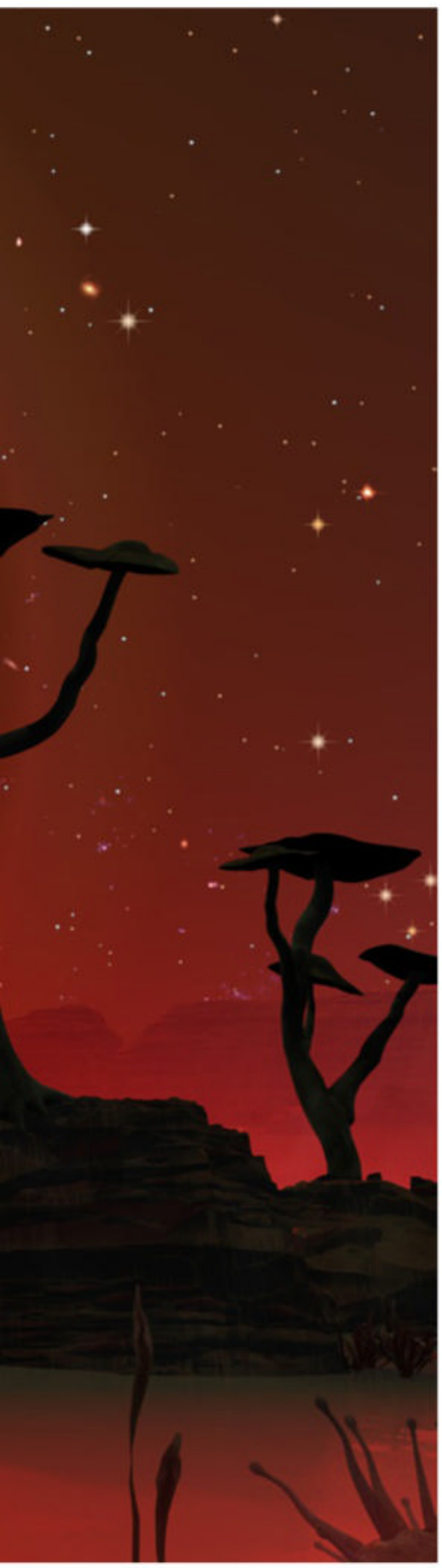
A barred spiral galaxy dominates the sky as it sets over the ocean of a distant planet populated with alien life forms.

JUSTIN DRAKE

View of a Pulsar From a Lonely Planet

Digital

A lifeless world is bathed in intense radiation from a quasar, even from tens of thousands of light-years away.



MARK A. GARLICK

Extra-Galactic Web

Digital

Extragalactic space is much more tenuous than interstellar space or the interior of the solar system, but even the emptiest places are not completely empty. Gas surrounds galaxies and exists between them in a great weblike structure called the cosmic web.

JUSTINAS VITKUS

Galactic Islands

Digital

The spiral arms of a galaxy are splayed in the foreground, bursting with hot, young stars giving off blue light. The radiation from these stars are energizing patches of hydrogen gas, which glow red.

ALDO SPADONI

Cradle of Life

Digital

The Next Generation Very Large Array (ngVLA) is the proposed successor to the Very Large Array. It would be the flagship facility of the National Radio Astronomy Observatory, which commissioned this artwork. The piece symbolically portrays ngVLA and the objects it will study.


ALDO SPADONI © 2017

Artists can drop us into the center of a distant gaseous whirlpool or spread a spiral arm of stars across the sky.

PATTY RAY AVALON

Messier 66

Acrylic

M66 is a spiral galaxy roughly 30 million light-years away in the constellation Leo. It has prominent dust lanes and an unusual arm structure that has been distorted by a gravitational encounter with another galaxy.

INDEX *of* ADVERTISERS

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ARTIST INFORMATION

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A scientific illustrator who creates visuals to inspire curiosity and promote science literacy, Adrianna has had work featured in *The Planetary Report* and *Ad Astra* magazines.
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PATTY RAY AVALON
A fine artist and muralist focusing on outer space imagery, Patty's involvement in art has spanned 30 years. Her current works blend scientific views, gathered from telescopes, with her personal interpretation.
avalonart.gallery

DANA BERRY
Both an illustrator and Emmy-nominated documentary producer, Dana specializes in science and astronomy. He has produced animations for many NASA missions and his artwork has appeared in numerous publications.
skyworksdigital.com

RICHARD BIZLEY
Richard paints astronomical and prehistoric scenes in acrylics, working in his English gallery. Born deaf, he enjoys engaging with the public and sharing the wonders of the cosmos.
bizleyart.com

CHRIS CALLE
With subjects ranging from the Apollo astronauts on the Moon to distant planets, Chris' work represents an artist who can be seen on everything from a U.S. postage stamp to enormous murals.
callespaceart.com

MICHAEL CARROLL
A founding member of the International Association of Astronomical Artists, Michael has produced work frequently seen in *Astronomy* and is the author of more than 30 books. He has received the Lucien Rudaux Memorial Award.
carrollspaceart.com

DANIEL DAHAN
An artist and videographer, Daniel has produced work that has been featured in many conventions and art shows. When he's not going on adventures or stargazing, he works on his YouTube channel, Adventure Art.
adventureartwork.com

DON DAVIS
A space artist and animator, Don is mainly focused on planetary surfaces and is also fascinated by deep space objects. Don is interested in impact dynamics of craters and large basins, and enjoys conveying science to the public.
donaldedavis.com

SAM DIETZE
A space artist and plein air artist, Sam has participated in many exhibitions, including Blair County Arts Festival, Southern Alleghenies Museum of Art, and Art of Possibilities. He has won numerous awards.
art-3000.com/artist/?id=5412

DON DIXON
The creator of cover art for *Astronomy*, *Scientific American*, and many books ranging from textbooks to science fiction novels, Don is an enthusiastic veteran. He was art director at Griffith Observatory for 29 years.
cosmographica.com

JUSTIN DRAKE
Inspired by the beauty of space, infinite potential landscapes, and the unknown, Justin creates both astronomical illustrations and science fiction artwork.
artstation.com/artistjaydrake

MARILYNN FLYNN
A science-based astro artist and illustrator, Marilynn merges her artistic talents with a lifelong passion for space exploration. Her works in acrylic, pencil, digital, and fiber media have been exhibited worldwide.
tharsis-artworks.square.site

JUSMENA FONSECA
A Brazilian space artist, Jusmena's favorite style is figurative. She draws and paints using various techniques such as graphite, charcoal, dry pastels, and oils, and models in clay.
iaaa.org/member-portfolio/?member=279

DOUG FORREST
An artist who creates graphite-pencil fine-art drawings that focus on the Apollo program, Doug has presented his work in *Astronomy* magazine and in the book *Imagining the Spheres: How We View Our Neighboring Worlds* (Steven Hobbs, 2018).
apollo-arts.com

MARK A. GARLICK
A former professional astronomer turned astro artist, Mark now devotes his time to creating realistic astronomy and space scenes, stills and animations, and paleo art. He is the author of several books.
markgarlick.com

DAVID A. HARDY
The longest-established space artist represented in this issue, David was first published in 1952. He is the author and illustrator of many books on astronomy, space travel, volcanoes, and geology. He has produced many book covers as well.
astroart.org

ROBIN HART
A lifelong love of space has led Robin to producing astronomical art. Working in many media, Robin has now shifted into producing many quilts as art pieces portraying nebulae and galaxies.
iaaa.org/member-portfolio/?member=57

WILLIAM K. HARTMANN
Internationally known as a planetary scientist, author, and painter, Bill is credited with originating, along with his colleague Donald R. Davis, the theory of the origin of the Moon. He was the first winner of the Carl Sagan Medal of the American Astronomical Society.
psi.edu/hartmann

GARRY L. HARWOOD
Studying for a career as a marine biologist and a physical oceanographer, Garry began painting full time in 2009 following two decades working in the jewelry industry. He lives and works in western Cornwall, U.K.
garryharwood.co.uk

PATTY HEIBEL
A sculptor and painter of deep space and Earth-based subjects, Patty has an expressive approach that is experimental. She translates the beauty of the cosmos into art that focuses on rich, resonant color and surprising texture.
heibelgallery.com

STEVEN HOBBS
With a Ph.D. in geographic information systems and remote sensing, Steven has actively researched and illustrated martian geomorphology, Earth-based analogues, and surface processes. His artwork has appeared in many books and magazines.
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MICHAEL LENTZ
As art director at NASA's Conceptual Image Lab, Michael provides guidance for the creation of art and animation, working agency-wide with scientists and producers to help bring their stories to life.
the-crayon.com

MARK MAXWELL
From multiple exhibitions at the Smithsonian Air & Space Museum to the first art exhibit in orbit on the space station MIR, Mark's work for NASA and other agencies has kept him busy.
iaaa.org/member-portfolio/?member=77

ERIKA A. MCGINNIS
With work shown at the U.S. Air Force Museum, Spacefest in Tucson, and the Johnson Space Center, Erika's career has also taken her to illustrate astronaut Ron Garan's children's book, *Railroad to the Moon* (New Epoch Publishing, 2021).
erikamcginnisart.com

RON MILLER
An illustrator and author specializing in astronomy, Ron's work appears regularly in *Astronomy* and *Scientific American*. His more than 70 books include *The Art of Chesley Bonestell* (Paper Tiger, 2001) and *The Art of Space* (Zenith Press, 2014).
black-cat-studios.com

THOMAS O. MILLER
A Cincinnati-based illustrator, Thomas has a background in fantasy, science fiction, and science fact. He has specialized in visualizing images in several scientific areas including medical, educational, and astronomical categories.
atomicart.com

WALTER B. MYERS
An illustrator specializing in science, astronomy, and space exploration, Walter has had work appear in books, magazines, museum exhibits, and on TV. His art strives toward photorealism with the goal of creating revealing images.
arcadiastreet.com

KEN NAIFF
Growing up in the bluebell-laden English countryside, Ken developed a passion for space. As an astroimager, Ken integrates art and science by capturing deep space pictures that are both thought-provoking and nurture a sense of wonder.
darkskyimagesbyken.com

NURUL SYAHIRAH BINTI NAZARUDIN
Popularly known as Syahirah Skygazer, Syahirah is an astronomical artist and dark-sky advocate in Malaysia. She strives to spread awareness of the cosmos and the importance of dark skies through her passion for education and astronomical art.
canvastocosmos.com

MARK PESTANA
Having served in the U.S. Air Force and at NASA as a research pilot, Mark teaches aerospace safety at the University of Southern California. His art is kept in NASA, Pentagon, and corporate collections, and he has designed nine space shuttle patches.
pestanafineart.wordpress.com

ROBIN PLEAK
A former engineer and amateur astronomer, Robin is now semi-retired and is happy to create art again after a 30-year hiatus.
robinpleak.com

JON RAMER
A career military officer and avid world traveler, Jon works in acrylics and oils, and digitally. His works have appeared in several astronomical and scientific art shows. He also recently coauthored and edited *The Beauty of Space Art* (Springer Nature, 2021).
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PAT RAWLINGS
Hundreds of magazines, books, television programs, and films have employed Pat's artwork. He has produced many finished pieces for NASA centers over a quarter-century, from robotic planetary missions to human exploration of Mars and beyond.
patrawlings.com

ALDO SPADONI
An aerospace engineer and futurist, Aldo has more than 35 years of experience supporting NASA and Department of Defense programs. An accomplished illustrator, concept designer, and Hollywood technical consultant, he is president of the International Association of Astronomical Artists.
fineartamerica.com/profiles/aldo-spadoni

NICK STEVENS
A digital artist based in Moldova, Nick specializes in unflown spacecraft projects and spacecraft of the Soviet Union, particularly the crewed Soviet lunar program.
nick-stevens.com

ZINA SVIDERSKIENE
An astrophysicist and longtime senior researcher at the Vilnius University Institute of Theoretical Physics and Astronomy, Zina breathes her passion for astronomy into artwork. She has authored and edited nine books.
iaaa.org/member-portfolio/?member=296

PRISCILLA THOMAS
Capturing the human touch in our reach for the stars, Priscilla reveres explorers and adventurers. She recently shared her art depicting the merging of space and the soul in a solo gallery exhibit titled "Space and Soul Together."
priscillathomasvisual.com

PETER THORPE
For more than 40 years, Peter has designed and illustrated book covers. He served as creative director of the Space Frontier Foundation for 20 years, and his rocket paintings are very well known in the space-art community.
peterthorpedesign.com

MICHAEL C. TURNER
Unique starscapes of cosmic phenomena characterize Michael's art, which he creates with traditional pigments and bristle-brush techniques on cloth canvases. He has been featured in many magazines and on the cover of *The Beauty of Space Art* (Springer Nature, 2021).
deviantart.com/astroboy1

JUSTINAS VITKUS
A self-taught Lithuanian artist with a long-time fascination with space, Justinas portrays space scenes based on both known and speculative worlds.
justv23.artstation.com

LUCY WEST
An award-winning professional artist, Lucy has focused on science, astronomy, and human evolution. Her works are featured in space-themed books, magazines, websites, events, and aerospace facilities.
lucyweststudios.com

DON WHITE
Memories of "drawing planets when all my friends were drawing dinosaurs" characterize Don's early entry into space art. He is now inspired by the journey of Voyager 2, and wonders what hitching a ride on that distant spacecraft would be like.
spacetravelart.com

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HUGE NEWS

ANNOUNCING

StarSense Explorer™ Dobsonian Telescopes

BY CELESTRON

Our patented sky recognition technology has redefined the manual telescope, guiding stargazers to celestial objects with pinpoint accuracy. Now, we've added even more light-gathering ability to the lineup. Meet the 8" and 10" StarSense Explorer Dobsonians.

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- Compatible with iPhone 6 and up & most newer Android phones

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2 LAUNCH THE STARSENSE EXPLORER APP

3 OBSERVE STARS, PLANETS AND MORE

ABOUT THE DOBSONIANS

- You'll enjoy dazzling views through the 8" or 10" Newtonian reflector optical tube featuring a parabolic primary mirror with highly reflective Celestron XLT coatings.
- The ultra-sturdy Dobsonian base features large diameter altitude bearings with variable tensioning, Teflon azimuth bearings, and braces on the side panel for extra stability.

Each StarSense Explorer Dobsonian includes:

- High-quality 25mm Plössl eyepiece
- 2" Crayford focuser
- StarSense smartphone dock
- StarPointer red dot finderscope
- Ergonomic carry handles and an eyepiece rack on the Dobsonian base

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September 2022

Jupiter dazzles all night

After months with few if any evening planets, September offers several solar system worlds at a decent hour. You'll first want to target **Mercury**, which is on the back end of its finest display this year. On September 1, the world stands 16° high in the west 45 minutes after sunset. Glowing at magnitude 0.4, it appears conspicuous in the twilight sky.

Although the inner planet dims and sinks closer to the horizon each day, it remains a fine sight for the next two weeks. On September 14, the magnitude 1.5 world hangs 10° high a half-hour after the Sun goes down. Be sure to follow Mercury's changing appearance through your telescope. On the 1st, the planet measures 8" across and is just under half-lit. By the 14th, it spans 10" and the Sun illuminates 16 percent of its Earth-facing hemisphere.

Saturn reached opposition in mid-August and now lies high in the east once darkness falls. The ringed planet shines at magnitude 0.4 and stands out against the much fainter background stars of eastern Capricornus.

September evenings find Saturn perfectly placed to view through a telescope. Even a small instrument reveals the planet's 18"-diameter disk surrounded by a stunning ring system that spans 42" and tilts 15° to our line of sight. The 8th-magnitude moon Titan also appears obvious. In moments of good seeing, the dark Cassini Division separating the outer A ring from the brighter B ring stands out. If you increase the aperture to 10 centimeters, a trio of 10th-magnitude satellites — Tethys, Dione, and Rhea — comes into view.

The solar system's largest planet, **Jupiter**, lies 45° east of Saturn along the ecliptic and thus trails about three hours behind its cousin. The giant world crosses from Cetus into Pisces on September 1 and continues to swim with the Fish the rest of the month. The planet gleams at magnitude –2.9 throughout September, far outpacing its starry surroundings.

Jupiter shines so brightly in part because it reaches opposition September 26. It then lies opposite the Sun in our sky and remains visible all night. It also approaches closest to Earth at opposition and thus shines brightest and looms largest when viewed with a telescope. The gas giant's equatorial diameter swells to 50" on the 26th, larger than any other planet can appear except for Venus when the inner planet is near inferior conjunction.

Plan to spend some time observing Jupiter once it climbs higher in the sky around midevening. Look for two parallel dark belts sandwiching a bright zone that coincides with the planet's equator. Moments of good seeing should reveal a whole series of alternating belts and zones. Also be sure to track the movements of Jupiter's four bright moons, which can change relative positions in as little as an hour.

Even **Mars** manages to rise by midnight local time in late September, though it comes up an hour later when the month begins. The Red Planet resides in Taurus, with its eastward trek starting between the magnificent Hyades and Pleiades star clusters and ending roughly two-thirds of the way from the Bull's head to the tips of the horns. Mars also brightens significantly during September, from magnitude –0.1 to magnitude –0.6.

This brightening coincides with the ruddy world coming closer to Earth and growing larger when viewed through a telescope. Mars' apparent diameter swells from 10" to 12" during September — big enough to show surface features under good seeing conditions. The best time to look is when the planet climbs highest in the sky as dawn starts to break.

Venus rises barely 30 minutes before the Sun in early September and is essentially lost from view. It will return to the evening sky in December.

The starry sky

Sagittarius the Archer lies nearly overhead as darkness falls in September, making this a great month to ponder the odd pattern of its star designations. Most backyard observers think the Greek letter designations German astronomer Johann Bayer developed in the early 1600s reflect the order of a star's brightness within a given constellation, with Alpha (α) the brightest, Beta (β) second, and so on. This is not strictly the case, however. Bayer grouped the stars in brightness classes and then assigned Greek letters within each class.

But Sagittarius doesn't even come close to this ideal: Alpha, Beta, Gamma (γ), Delta (δ), and Epsilon (ε) Sagittarii actually run in order of increasing brightness! It pays to remember that Bayer observed from Augsburg, Germany, at a latitude of 48° north, where Sagittarius hangs low in the sky. In fact, Beta never rose above his horizon, and Alpha barely did.

Star names have always fascinated me. Perhaps the most intriguing one in Sagittarius is magnitude 2.1 Nunki (Sigma [σ] Sgr), the Archer's second-brightest star. The name comes from the Sumerian *Tablet of Thirty Stars*, in which it is star number 29.

Yet Nunki wasn't originally applied to Sigma Sgr. In the late 1800s, author Robert Brown identified Nunki with Altair (Alpha Aquilae); a century later, Ian Ridpath suggested the name actually applied to a group of stars. Whatever its origin, Nun-ki was the cuneiform representation of the ancient Sumerian city of Eridu, which today is a relatively small archaeological site in Iraq called Tell Abu Shahrain, not far from the larger site of Ur.

STAR DOME

HOW TO USE THIS MAP

This map portrays the sky as seen near 30° south latitude. Located inside the border are the cardinal directions and their intermediate points. To find stars, hold the map overhead and orient it so one of the labels matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at:

10 P.M. September 1
9 P.M. September 15
8 P.M. September 30

Planets are shown at midmonth

MAP SYMBOLS

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

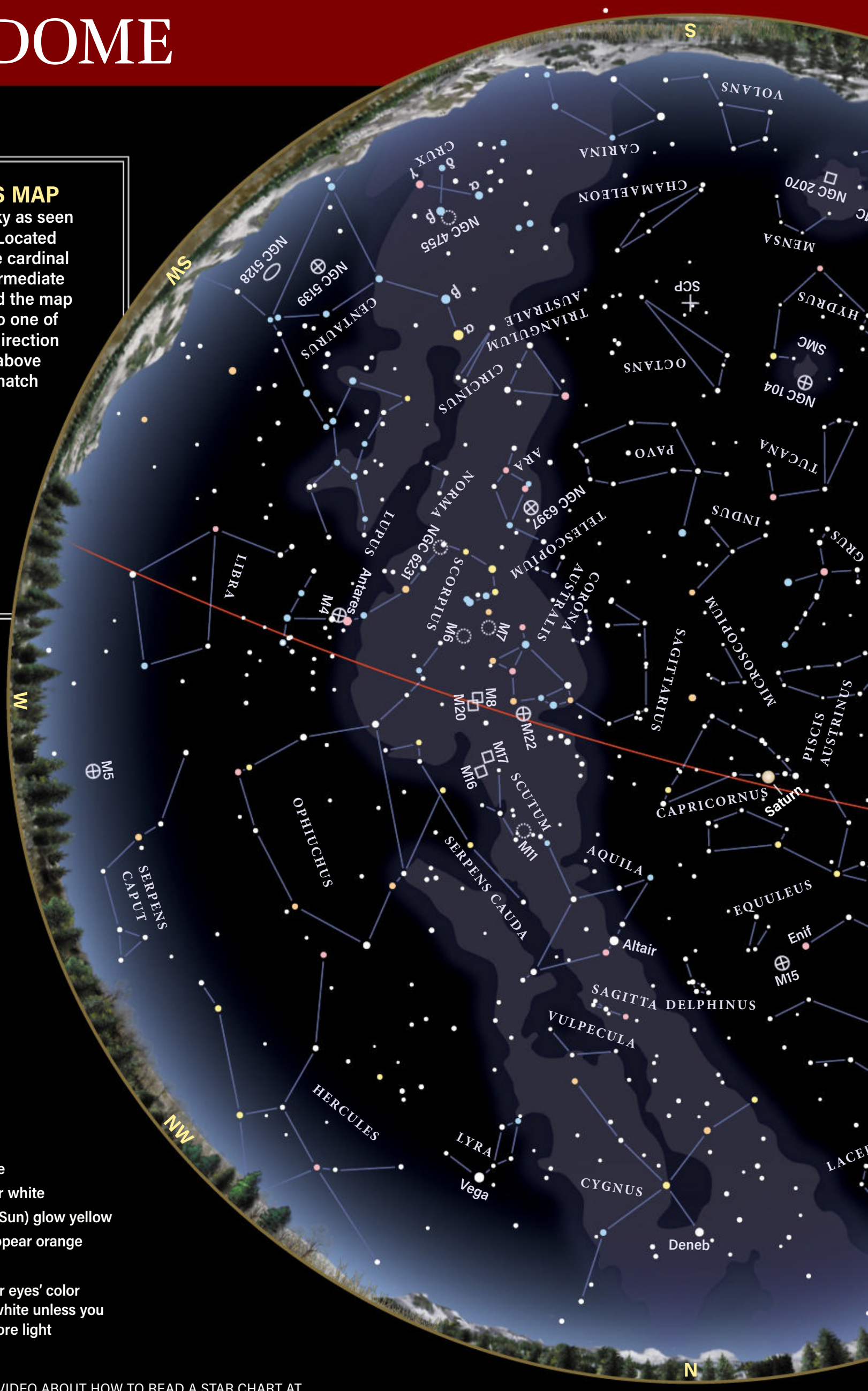
STAR MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

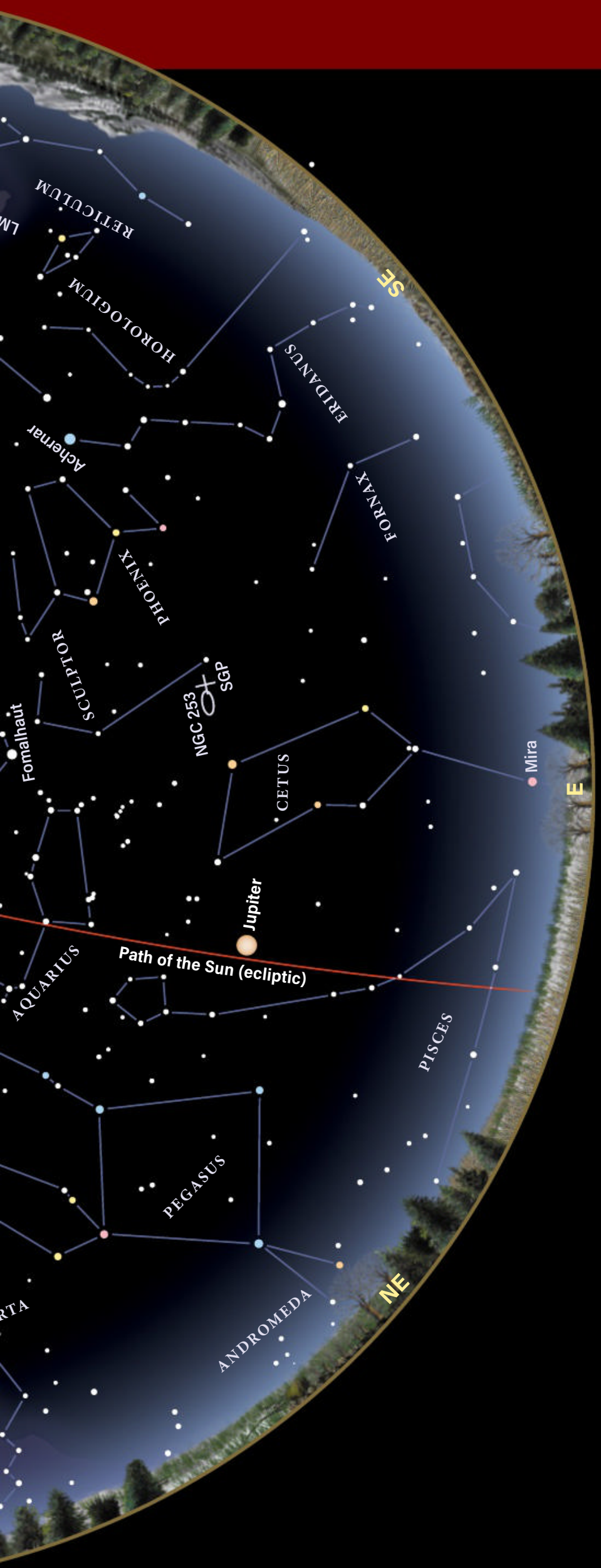
STAR COLORS

A star's color depends on its surface temperature.

- The hottest stars shine blue
- Slightly cooler stars appear white
- Intermediate stars (like the Sun) glow yellow
- Lower-temperature stars appear orange
- The coolest stars glow red
- Fainter stars can't excite our eyes' color receptors, so they appear white unless you use optical aid to gather more light



BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**



SEPTEMBER 2022

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.

CALENDAR OF EVENTS

3 First Quarter Moon occurs at 18h08m UT

5 Venus passes 0.8° north of Regulus, 1h UT

7 Asteroid Juno is at opposition, 17h UT

The Moon is at perigee (364,492 kilometers from Earth), 18h19m UT

8 The Moon passes 4° south of Saturn, 11h UT

9 Mars passes 4° north of Aldebaran, 1h UT

Mercury is stationary, 20h UT

10 Full Moon occurs at 9h59m UT

The Moon passes 3° south of Neptune, 19h UT

11 The Moon passes 1.8° south of Jupiter, 15h UT

14 The Moon passes 0.8° north of Uranus, 23h UT

16 Neptune is at opposition, 22h UT

17 The Moon passes 4° north of Mars, 2h UT

Last Quarter Moon occurs at 21h52m UT

19 The Moon is at apogee (404,556 kilometers from Earth), 14h43m UT

23 September equinox occurs at 1h04m UT

Mercury is in inferior conjunction, 7h UT

25 New Moon occurs at 21h55m UT

26 Jupiter is at opposition, 20h UT

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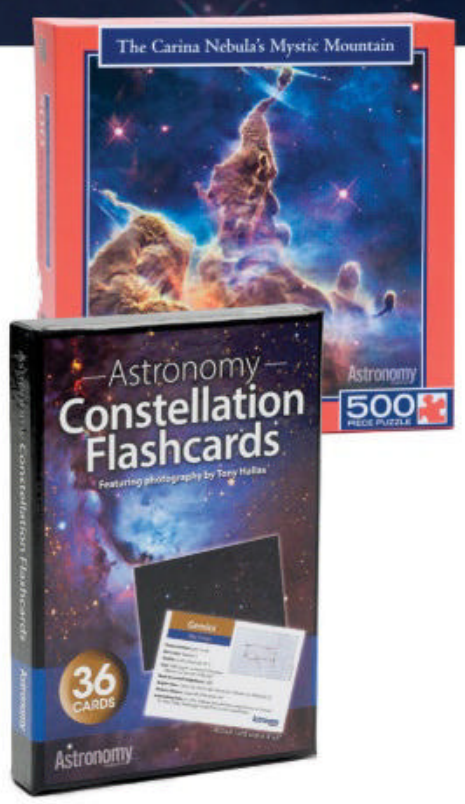

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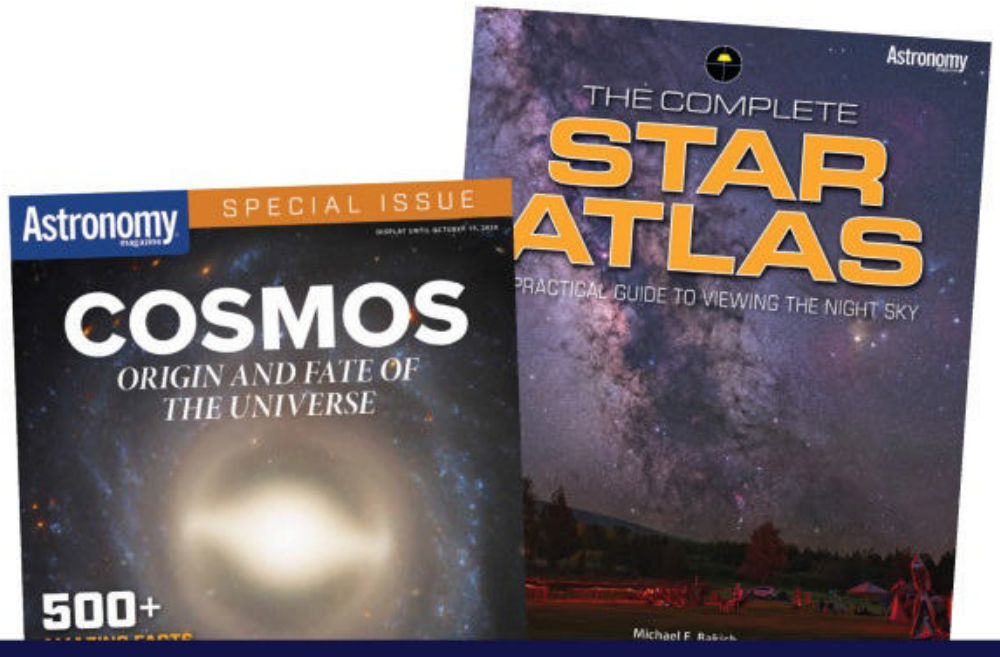

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